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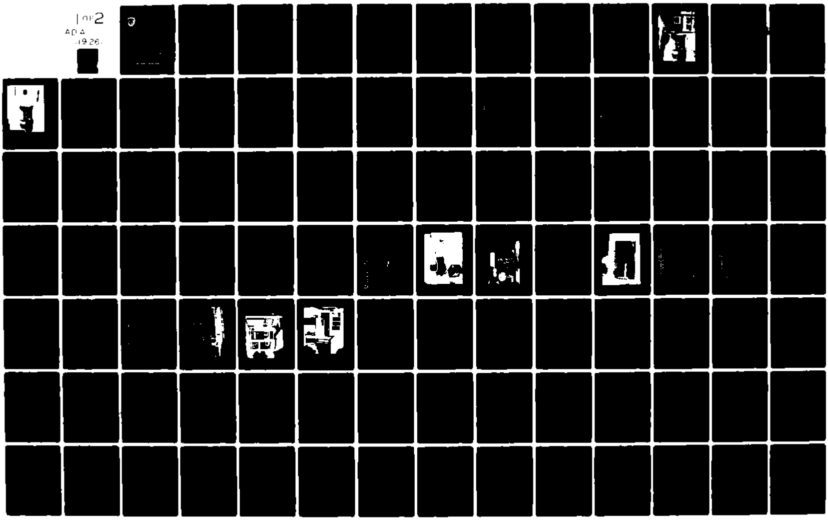

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OF

FIRE CONTROL ALL WEATHER (POINTING ANGLE MEASUREMENT SYSTEM (PAMS))

AUGUST 1982

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The requirement for all weather fire control instrumentation for use in testing gun air defense weapon systems resulted in the development of a pointing angle measurement system (PAMS) using video correlation and centroid tracking techniques. The development and testing of PAMS was supervised by the Materiel Testing Directorate (MTD) of Aberdeen Proving Ground (APG) during the period from October 1977 to April 1982. A description of the system's theory of operation and software techniques is included in the report. The report concludes

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20. that: (1) the tracking accuracy of PAMS within the constraints of track point definition is within the ±1 mrad specified for the system; (2) PAMS does not reliably track targets at rates above 54°/sec; and (3) PAMS can be successfully integrated into air defense systems testing. It is recommended that: (1) PAMS be used on all tests of gun air defense weapon systems; (2) additional modification be made to PAMS to improve its tracking rates and limited conditions of visibility. Further accuracy tests are also recommended for PAMS.

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ABSTRACT

The requirement for all weather fire control instrumentation for use in testing gun air defense weapon systems resulted in the development of a pointing angle measurement system (PAMS) using video correlation and centroid tracking techniques. The development and testing of PAMS was supervised by the Materiel Testing Directorate (MTD) of Aberdeen Proving Ground (APG) during the period from October 1977 to April 1982. A description of the system's theory of operation and software techniques is included in the report. The report concludes that: (1) the tracking accuracy of PAMS within the constraints of track point definition is within the ±1 mrad specified for the system; (2) PAMS does not reliably track targets at rates above 54°/sec; and (3) PAMS can be successfully integrated into air defense systems testing. It is recommended that: (1) PAMS be used on all tests of gun air defense weapon systems; (2) additional modification be made to PAMS to improve its tracking rates and limited conditions of visibility. Further accuracy tests are also recommended for PAMS

The MTD, APG was responsible for the overall supervision of the study, system integration, and the preparation of the final report. Westinghouse Electric Corporation, Defense and Space Center, Systems Development Division was responsible for development of the microprocessor algorithms and construction of the PAMS hardware. Special recognition is given to Mr. James Fawcett and Dr. Martin Woolfson of Westinghouse, Inc. whose contributions were essential to the success of the system.

SECTION 1. BODY

1. BACKGROUND

The most basic measurement required in all tests of gun air defense weapon systems is the angle between the gun axis and the target. In typical gun air defense tests, this measurement is complicated by the following constraints:

a. Target size varies from 0.5 to 80 mrad in a given mission.

b. Target shape varies widely in a given mission.

c. Background variations from clear sky to mountains are encountered.

d. Target rates of up to 75°/sec are encountered.

e. The target cannot easily be made cooperative.

f. The measurement variable can be as large as 400 mrad.

In the past, three techniques have been used to measure pointing angle. The first of these, a photographic technique, requires that a large format film camera be mounted and alined to the weapon system and operated during the test mission. The film is processed and target position determined days to weeks after the completion of the mission. This method of data acquisition is inherently vulnerable to quality control inadequacies and is a slow, manpower intensive process.

The second technique utilizes shaft angle encoder and weapon platform tilt information in conjunction with an independent ground based target tracking radar to determine weapon system pointing angle. Since the platform tilt measuring instrumentation and target tracking radar are required for other purposes, this method for cost reasons has enjoyed great popularity. Unfortunately, the accuracies required to effectively evaluate weapon system performance have not been attained, and historically error accumulations have exceeded 5 mrad. The complexity of the combination of data from different sources has eliminated real-time checks.

The third method for determining pointing angle uses a passive television and video tracker. With this instrumentation system, real-time data is available. However, the field of regard required and the differing ranges over which testing is conducted has limited the applicability of this method.

2. OBJECTIVE

The objective was to develop an all-weather instrumentation system capable of providing a precise measurement on a real-time basis of the angle between the line of sight (LOS) of an air defense weapon system and the intended target.

3.1 POINTING ANGLE MEASUREMENT SYSTEM (PAMS)

The PAMS is a compact, high performance electro-optical system designed for precision angle tracking of extended or point targets. By using video correlation or centroid tracking techniques, the system provides accurate tracking and angle readout of airborne targets during dynamic flight conditions from a moving vehicle undergoing various motions of shock and vibrations.

PAMS consists of the sensor/turret assembly, an electronics unit, and a control station as shown in figure 3-1. The sensor/turret assembly contains a turret which rotates in azimuth to provide course LOS direction. Within the turret is a gyro stabilized, two-axis gimbal which provides precision direction in azimuth and elevation. The sensor/turret is shock and vibration isolated from the base. Located under the sensor/turret is a field-of-view switchable optics assembly, a video camera, and two charge coupled device (CCD) sensors which measure the angles between the sensor and the base.

The electronics unit contains all those elements required for communications, data processing, autotracking, servo control, and power conversion and distribution.

The control station contains a front panel assembly, a force stick, and a video annotator. All system operating controls and indicators are located either on the force stick or control panel.

Table 3-1 contains the specifications for the PAMS.

3.1 (Cont'd)

Figure 3-1. Pointing angle measurement system.

Name	Characteristics
Television	
Output	1V, 75 ohms EIA Std RS170
Camera tube	1-inch magnetic silicon vidicon
Target area	12.8 mm by 9.6 mm
Aspect ratio	4 by 3
Synchronization	Genlocked to master clock
Light level control	T/14 to T/112
System data rate	30 Hz serial, time-multiplexed
Azimuth pointing angle	16 bits, 2's complement, transistor-transistor logic (TTL), 1 mrad, rms, accuracy
Elevation pointing angle	14 bits, TTL, 1 mrad, rms, accuracy
LOS stabilization	Rate gyros, 20 Hz, BW
Tracker, video auto.	
Master clock	18.144 MHz
Clock phases	6.048 MHz
Genlock TV sync	504 KHz
Type	Binary correlation target centroid
Track window	Agile, 32 by 32 television lines (TVL)
Track rate	75°/sec
Minimum vert/horiz sample	1 TV line/frame, 16.5 nsec
Gimbal	
Azimuth	360°
Elevation	-5° to $+105^{\circ}$
Angle encoders (El, A_o, A_i)	14 bits, 0.6 mrad accuracy

3.1.1 Operational Overview

PAMS is designed to be directly mounted on a gun air defense weapon system or other tracking system. The electronics unit provides azimuth and elevation outputs of the PAMS sensor/turret assembly LOS with respect to its base in the form of two 16-bit words. An input is provided on the electronics unit to apply a reference pointing angle (an azimuth and elevation). In acquisition mode, the PAMS gimbal system is slaved to this input. The pointing angle from the guns, the tracking radar, or the gunner's sight can be applied to this input to enable PAMS to follow the tracking of one of these systems. The PAMS operator, working from the control station with its video display, will use acquisition mode to initially spot the target.

Switching to manual mode, the PAMS gimbal system will respond to pressure applied to the force stick at the control station. Depending on the target size, the operator can select from three fields of view and three gate sizes. The track processor performs an autocorrelation on the image within the gate and indicates to the operator whether the image has sufficient contrast for the processor to carry out correlation tracking. For targets with a high angular speed moving across a relatively uncluttered background, a centroid tracking mode is available.

3.1.1 (Cont'd)

When the processor indicates that it has a trackable target, the operator can depress the trigger on the force stick and PAMS will lock onto the target in auto track mode. In centroid track mode, the processor will perform automatic centering and automatic gate size selection. In correlation track mode, the track point may drift due to the changing size and shape of the target. The operator can adjust the track point by using the offset track mode.

Figure 3-2 is a photograph showing the location of each control and indicator on the control panel or force stick. Table 3-2 lists these controls and indicators along with a brief functional description.

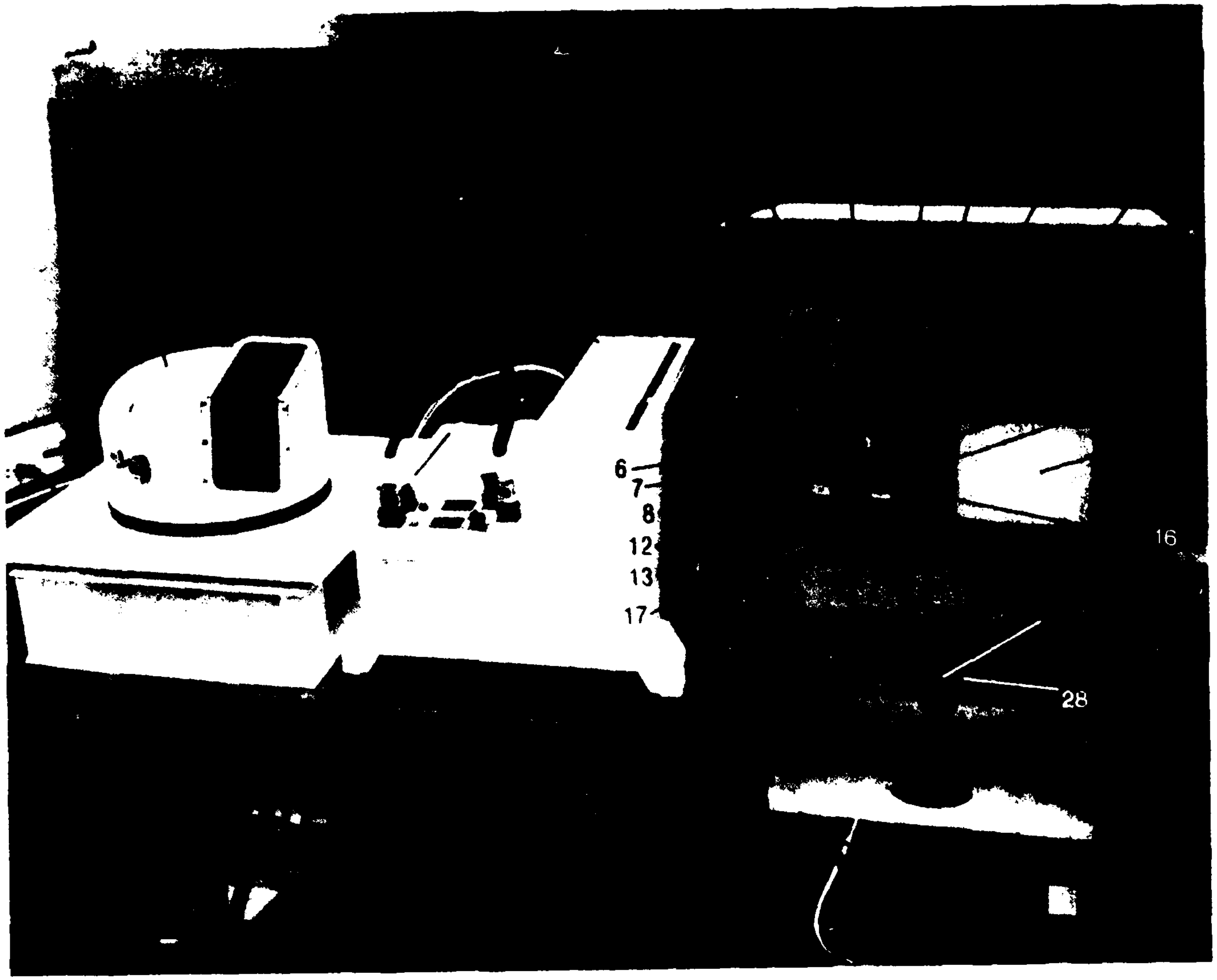


Figure 3-2. PAMS controls and indicators.

3.1.1 (Cont'd)

TABLE 3-2. CONTROLS AND INDICATORS

Name	Index	Function
SYSTEM MODE		
CAGE	1	This switch/indicator causes the servo system to drive the turret and two-axis gimbal to 0^{o} azimuth and elevation with respect to the mounting base.
ACQ	2	The acquisition mode is a command position mode derived from external angle inputs. The PAMS line-of-sight is slaved to these inputs when this switch/indicator is pressed.
MNL TRK	3	This indicator lights when manual track mode is selected on the force stick.
AUTO TRK	4	This indicator lights when auto track mode is selected on the force stick.
OFS TRK	5	This indicator lights when offset track is selected on the force stick.
FOV		
1.3 FOV	6	This indicator lights when 1.3-degree field-of-view is selected by a button on the force stick.
3.6 FOV	7	This indicator lights when the 3.6-degree field-of-view is selected.
10 FOV	8	This indicator lights when the 10-degree field-of-view is selected.
NORM/UNDERSCAN	9	This is a dual function switch/indicator. When NORM is selected, the vidicon target is scanned normally. When UNDERSCAN is pressed, the target scanned area is reduced

3.1.1 (Cont'd)

TABLE 3-2 (CONT'D)

Name	Index	Function
		3:2. This has the effect of magnifying the object of interest in the FOV.
WEAPON ANGLE LIMIT		
AZ WAL	10	This indicator lights when the turret rotates past the position preset by the AZ LIMIT switch on the Electronics Unit.
EL WAL	11	This indicator lights when the mirror moves in elevation past the position preset by the EL LIMIT switch on the Electronics Unit.
GATE SIZE		
SM	12	When pressed, this switch/indicator selects a 32 TVL tracking gate for the tracker.
MED	13	This switch/indicator selects the 64 TVL size tracking gate.
LG	14	This switch/indicator selects the 128 TVL tracking gate.
VIDEO		
ANLG/DGTL	15	This dual function switch indicator selects the video display mode. When ANLG is selected, the display video is taken directly from the camera output. When DGTL is selected, the digitized video that is input to the tracker is converted to analog and displayed on the monitor.
TRACKER MODE		
CORR/CENT	16	This dual function switch/indicator selects the tracker mode commanded to the electronics unit. CORR selects correlation track mode; CENT selects centroid track mode.

3.1.1 (Cont'd)

TABLE 3-2 (CONT'D)

Name	Index	Function
FOCUS		
IN	17	When pressed this switch/indicator causes the optics in the sensor/turret assembly to shift the focal point closer to the sensor giving better FAR focus.
OUT	18	This switch/indicator shifts the focal point a greater distance from the sensor giving better NEAR focus.
BORESIGHT		
BSC	19	This switch/indicator selects the boresight mode. This lights the boresight LED during one field of every third TV frame, permiting the automatic boresight circuits to shift the TV scanning position to compensate for changes in boresight. The TV camera must be viewing a dark scene, and the 1.3 or 3.6 degree FOV and must be selected. The 10-degree FOV cannot be used in this mode.
POWER		
ON	20	This switch/indicator alternately turns the control station on and off each time it is pressed.
DATA RATE	21	This is a variable control: Clockwise rotation increases the data rate to the SYSTEM STATUS control station display. Counterclockwise rotation reduces the data rate to the SYSTEM STATUS control station display.

3.1.1 (Cont'd)

TABLE 3-2 (CONT'D)

Name	Index	Function
SYSTEM STATUS	22	This 32-character LED display provides the following information. See Figure 2-2.

Digits (left to right)

1-9 Azimuth error in radians

10 Blank (when system operating)

11-19 Elevation error in radians

20 Blank (system operating)

21-26 Readout depends on system mode as follows:

22-26 CAGED

21-26 MANTRK

22-24 ACQ

22-25 AUTO

21-26 OFFTRK

22-26 COAST

When the control station is turned on and, for any reason, communication is not acknowledged from the sensor location, digits 10-22 display the following:

STANDBY

27 - Blank

28 - Displays C (check sum error) when data link inaccurate.

29 - Displays B when boresight is locked up.

30 - Blank

31 - Displays R if target is trackable

3.1.1 (Cont'd)

TABLE 3-2 (CONT'D)

Name	Index	Function
		32 - Displays 0 or 1 alternately, indicating which reference RAM is being used when in correlation mode. Displays T when in centroid track mode.
TV DISPLAY	23	This display shows the video signal. A crosshair indicates the point of boresight. A window pattern surrounds the target area being tracked in the auto track mode. Also displayed in the video monitor is annotation containing information similar to that on the system status display. See Figure 2-3.
FORCE STICK	24	Force applied in a left/right or forward/aft direction causes the LOS to change in azimuth or elevation, respectively. (Not applicable in ACQ mode.)
Manual Track	25	This button switch selects manual track mode when pressed.
Field of View	26	This switch selects 1.3-, 3.6-, 10-degree FOV.
Trigger Switch	27	This switch selects auto track mode when pressed to the first detent. When pressed to the second detent and tracking in correlation mode, centroid track is invoked until the switch is released.
Track Mode	28	The first time this switch is pressed, the offset track mode is selected. When pressed again, normal track is selected. In this manner alternate selection of offset and normal track modes is effected.

3.1.2 Theory of Operation

A block diagram of PAMS is shown in figure 3-3. The electronics unit is the center of activity in that it acts as a master processor to the slave processor control station in addition to controlling the functions of the sensor/turret.

The sensor/turret is shown in block diagram form in figure 3-4. This contains the television camera, optics, two-axis gimbal, and elements of the servo system. Figure 3-5 is a block diagram of the electronics unit which contains the video processing circuits, autotracker, automatic boresight, control link communication, and the remainder of the servo system. Figure 3-6 is a block diagram of the control station.

Examination of figures 3-5 and 3-6 demonstrates that PAMS relies heavily on microprocessor technology. The control station is configured with a microprocessor that scans the control panel and force stick inputs, handles communications with the electronics unit, and services the outputs and displays.

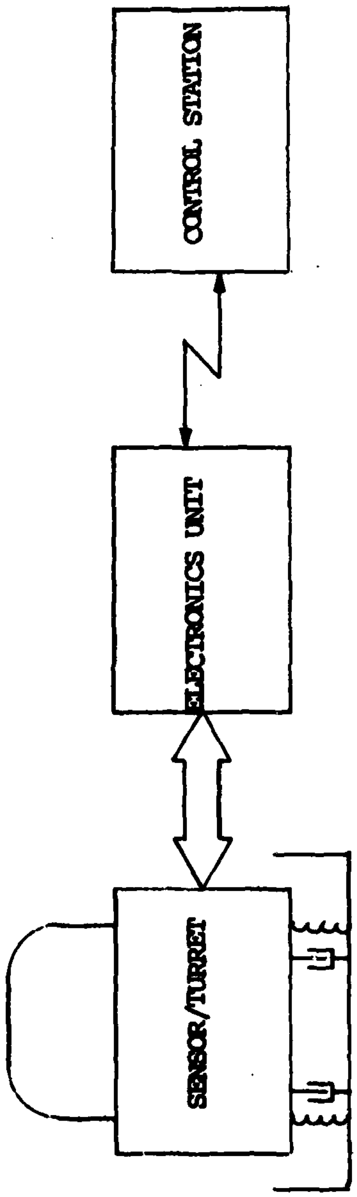


Figure 3-3. PAMS block diagram.

3.1.2 (Cont'd)

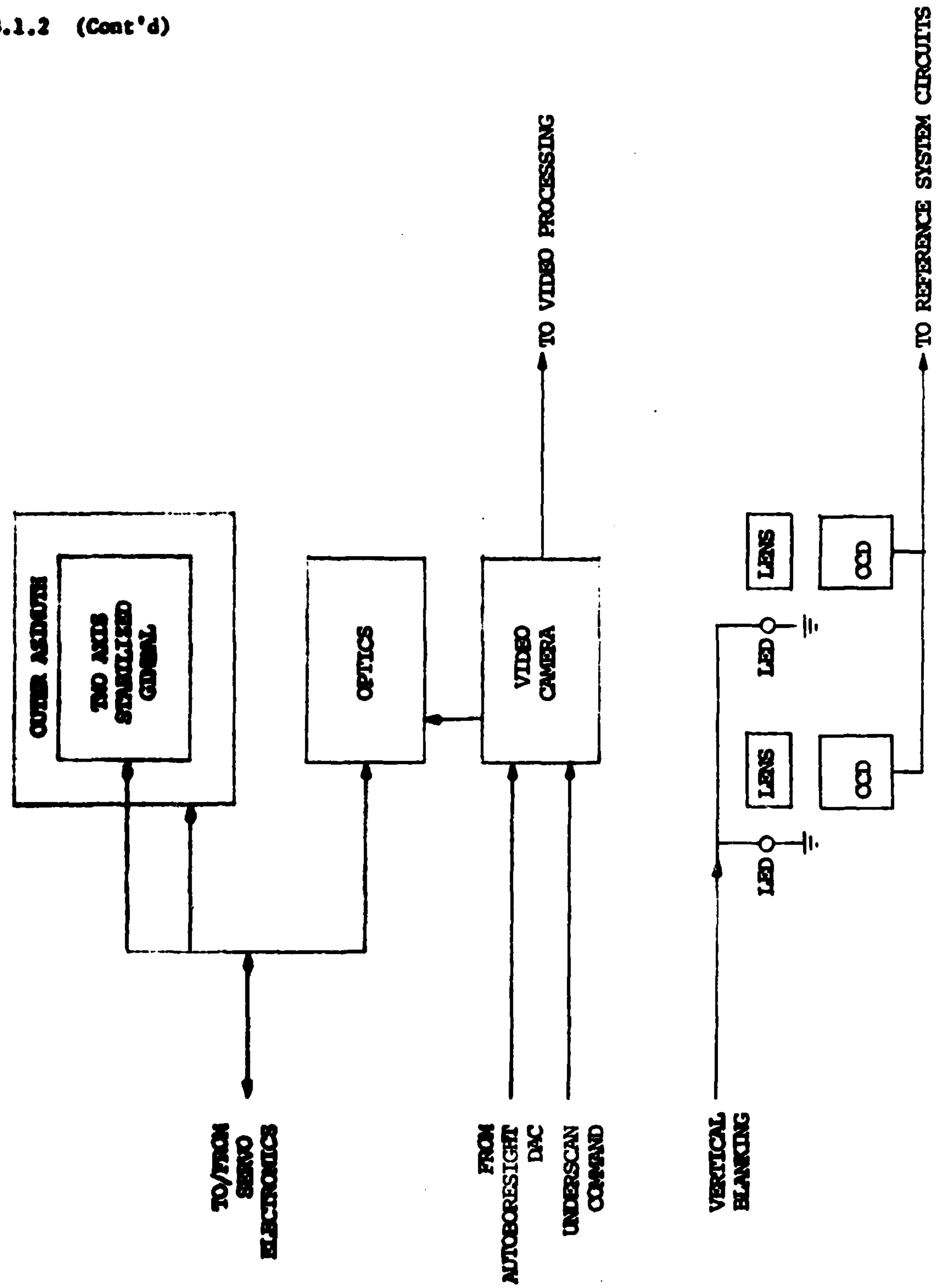


Figure 3-4. Block diagram of PAMS sensor/turret.

3.1.2 (Cont'd)

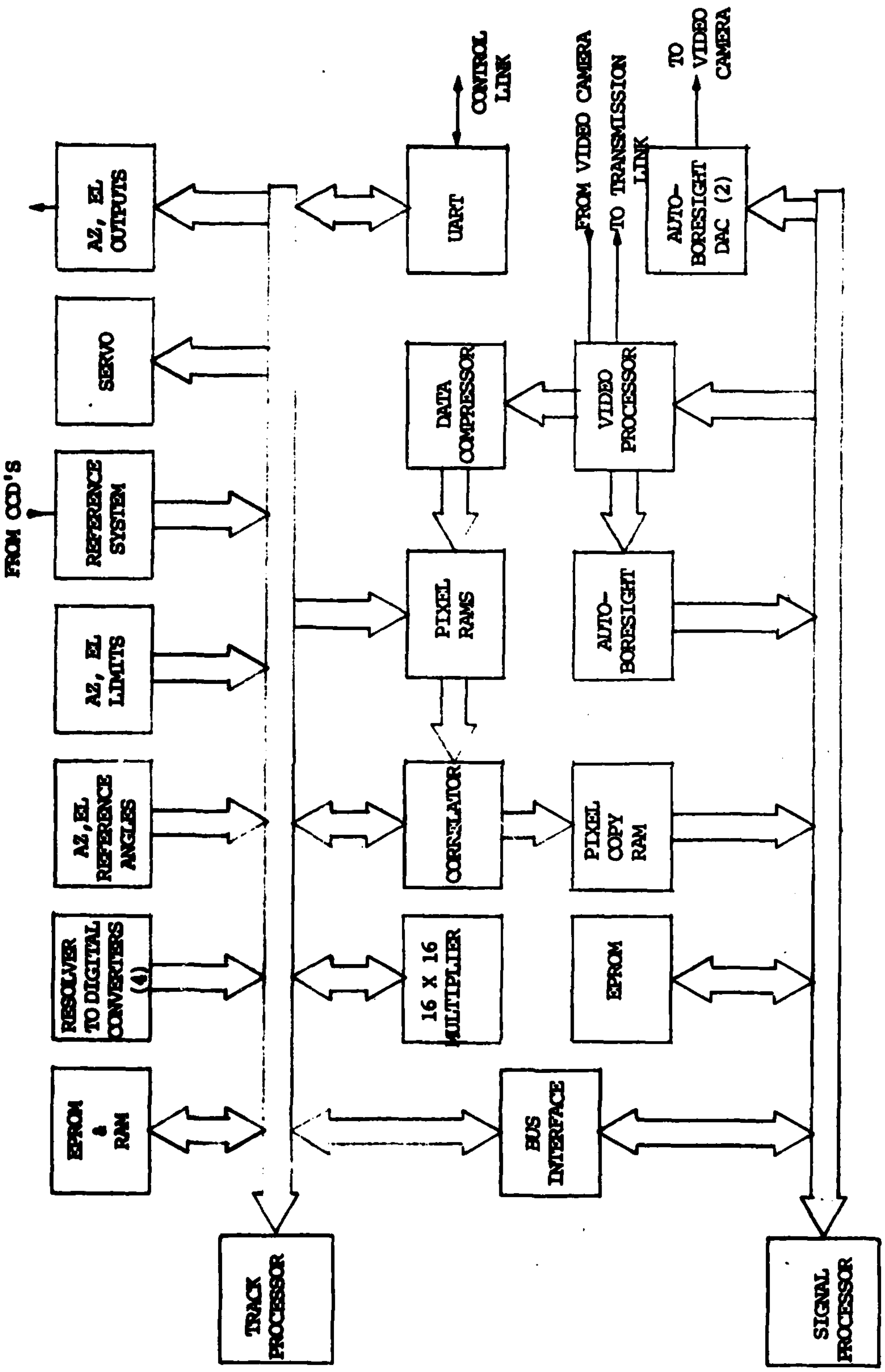


Figure 3-5. PAMS electronics unit block diagram.

3.1.2 (Cont'd)

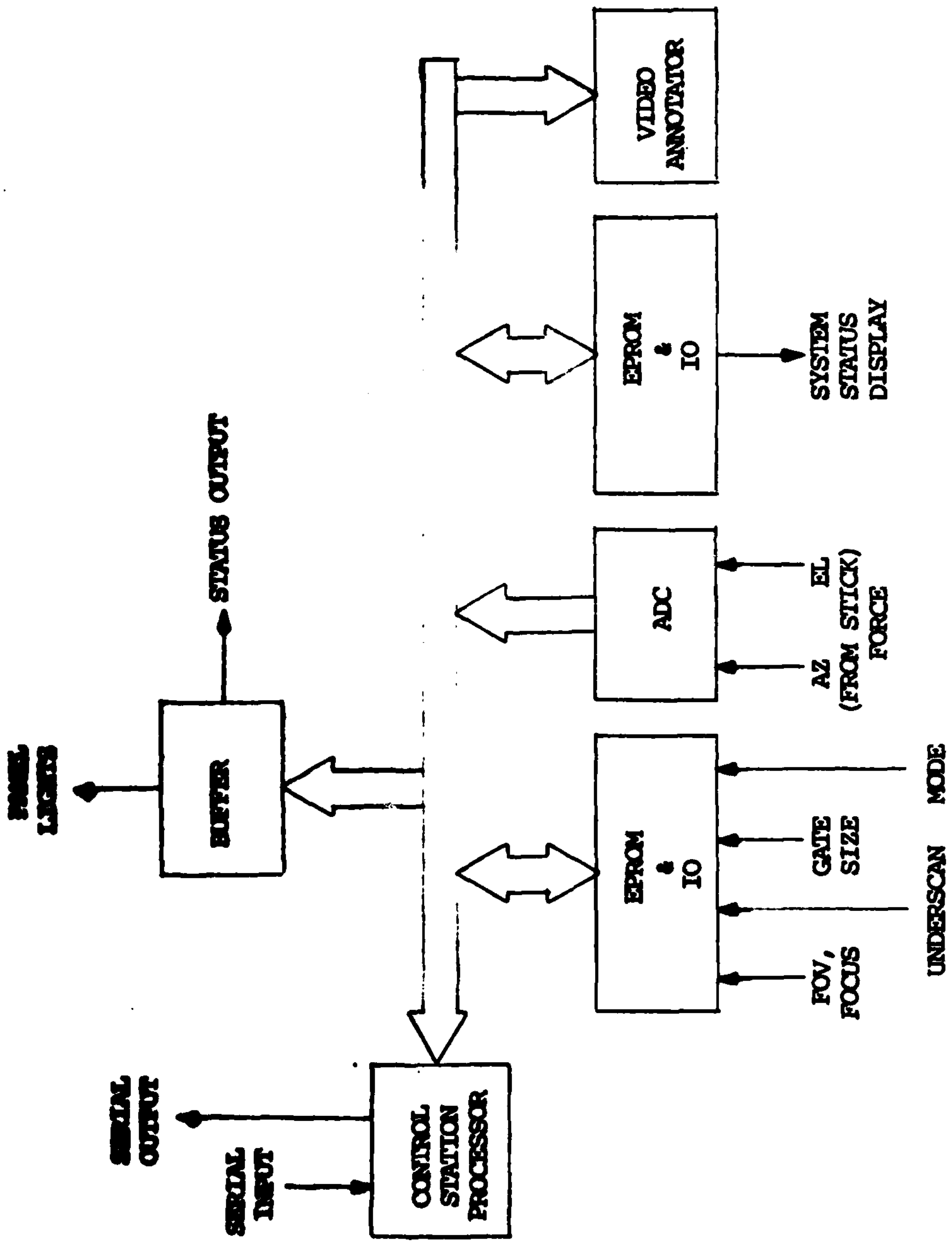


Figure 3-6. PAMS control station block diagram.

The electronics unit is based on two microprocessors, the track processor and the signal processor. The track processor is the system master, and performs the functions of communications, correlation autotrack, servo control, reference system corrections, limit checking and system outputs. The signal processor is responsible for performing the centroid tracking calculation, auto boresight, and control of the gray level mapping circuits. Each of these processors in the electronics unit has its own local bus and, in addition, there is an interface between the two buses.

PAMS employs two track modes. The first of these is the correlation track mode. In this mode, a minimum absolute distance (MAD) correlation calculation between the current scene and a dynamic reference is performed with the point at which the minimum occurs indicating the position of the target. Correlation calculations are carried out using a combination of hardware and software. In the alternate centroid track mode, which is performed entirely by the signal processor software, the target position is deduced by calculating the target centroid. Both track modes actively process data at all times, with the tracker as selected by the mode control switch (or trigger override control) providing the track error signals for the servo system.

The following paragraphs describe the major elements of PAMS and their functions. This discussion is referenced to figures 3-4, 3-5, and 3-6.

3.1.2.1 Gimbal and servo system. The gimbal controls the PAMS LOS. The LOS is pointed to the target via a two-axis gimbaled mirror which is stabilized in azimuth and elevation, a rotating turret, and part of the optics system mounted in the turret. The system is mechanized so that for elevation angles from -5^{o} to $+80^{o}$, the turret is driven by the two-axis gimbal to null the stabilized mirror in azimuth. Above 80^{o}, control logic permits the stabilized mirror to operate off its null axis, thereby providing continuous tracking near and through the zenith where a two-axis gimbal would encounter a pole.

The inner, gyro-stabilized gimbal provides inertial isolation of the LOS from base and vehicle motion. Sliprings are used to permit the turret to move continuously in azimuth.

The inner azimuth circuits include a torquer, a gyro, and a resolver. The elevation circuits include similar items. The outer azimuth circuits include a turret motor and a tachometer (in lieu of a gyro) and a resolver.

When the two-axis gimbal is commanded to point in a given direction, the command is executed in the form of a voltage applied to torquer windings in the gyros. This causes the gyro to precess and a voltage is induced in a pick-off winding in the gyro. The pick-off winding voltage is applied to the servo which generates drive voltage to the gimbal torquer motors. The motors drive the gimbal in the direction required to null the pick-off winding voltage, at which time the LOS is pointing in the proper direction and the servo removes drive from the torque motors.

The track processor provides the control input to the servo system. The LOS and derotation positions are input to the track processor via resolver-to-digital converters. The servo positions are output through digital-to-analog converters attached to the track processor data bus. The servo system operates independently to maintain the LOS as directed.

3.1.2.2 Optical system. PAMS employs an optical system which provides three optical fields of view with high resolution. A camera underscan feature enables an additional 1.5 to 1 magnification to be obtained.

A functional diagram of the optical system is shown in figure 3-7. As indicated, the scene in the LOS is reflected from the stabilized mirror to a fixed mirror which directs the image downward through an objective lens to the autoboresight prism. At this point, the autoboresight light emitting diode (LED) can be injected into the optical path as desired. The image is then reflected 90° through a switchable relay lens. The position of this relay lens determines the field of view (FOV). The image is then reflected twice through 90° by mirrors and passes through a lens, light control filter, and derotation prism to the TV camera vidicon. The f/No. is maintained at a value of 10 in all FOVs. The light control filter permits the T/No. to be controlled from a minimum value of 14 to a maximum value of 112. This provides an optimum camera light level over a wide range of scene illumination levels. The derotation prism is rotated by the derotation circuits to counteract the image rotation caused by the movement of the stabilized mirror in elevation and azimuth.

The video camera provides the means for viewing the target. The camera is of the type developed for use in the harsh shock and vibration environments encountered in weapon system testing. The camera was modified to provide control signals to the filter wheel circuits to maintain the proper light level to the video sensor.

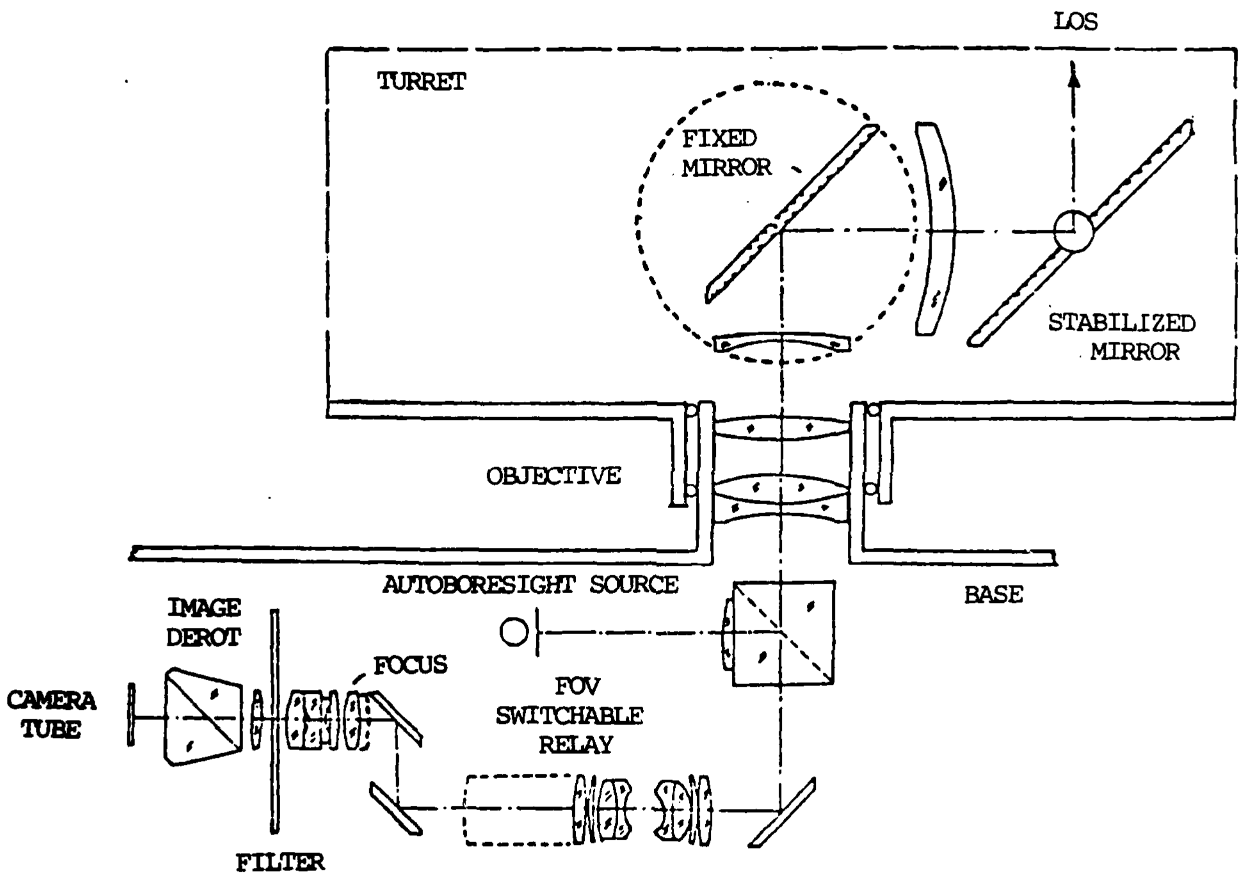


Figure 3-7. Composite optical system.

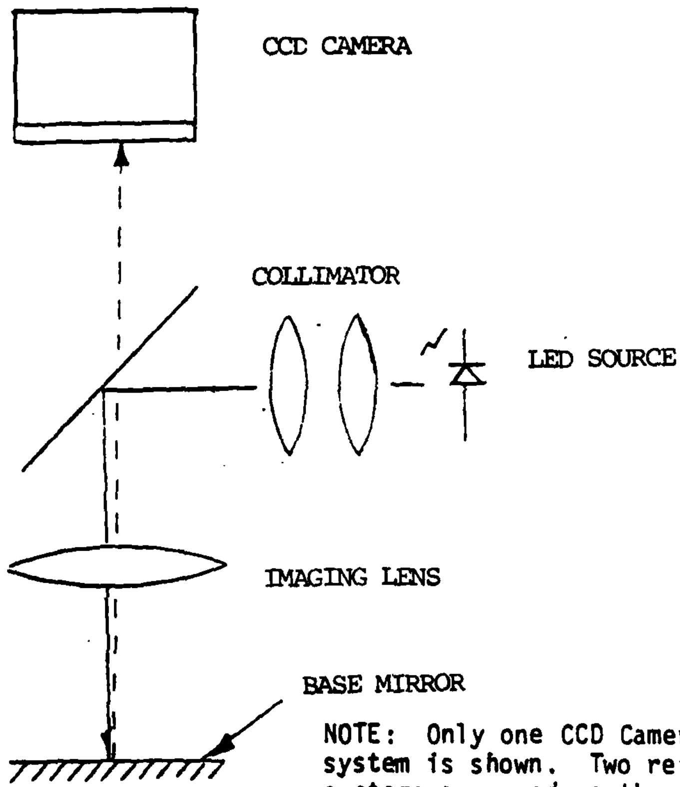
3.1.2.3 Reference system. PAMS is isolated from the weapon system by shock isolators and hence, angular motions may occur at magnitudes which exceed the required measurement accuracy. A method of dynamically measuring the angle of the system with respect to the turret is employed and corrections are made. The method utilizes an optical system to avoid interference with the shock isolators. The reference system uses two CCD cameras in an auto-collimator type configuration to measure the angular motion which can occur in three axes: roll, pitch, and yaw.

A simplified diagram of the optical method of measurement is shown in figure 3-8. For simplicity, only one CCD system is shown although two are used. The two are mounted at right angles to each other in order to measure the three axes of motion.

A collimated point of light is projected to a mirror mounted on the turret. This point of light is reflected to the CCD camera. When the mirror plane and CCD camera axis are perpendicular, the reflected spot falls on the center of CCD scan. Any angular motion causes the spot to move from the center of the CCD scan. The position of the spot is thus a function of the angle between the mirror plane and the CCD scan plane.

The point of light is generated by turning on a LED. The vertical sweep of the CCD is shifted with respect to the TV camera sweep so that the LED energizes during the TV vertical blanking, but in the center of the CCD scan pattern. The position of the spot is detected and measured using counter circuits. The counters are preset such that if the LED pulse image is centered properly, no error output is generated. If, due to shock or vibration, the pulse image is not centered, error signals are generated. The errors are processed and correction signals are sent to the servo system under program control. The autotrack circuits employ an agile gate to compensate for those errors outside the servo slew rate.

3.1.2.3 (Cont'd)



NOTE: Only one CCD Camera reference system is shown. Two reference systems are used, orthagonal to each other.

Figure 3-8. CCD camera reference system, simplified diagram.

3.1.2.4 Video processing. There are two major video signal paths within the PAMS electronics unit. First, the video signal is amplified in two stages for coupling to the video link for transmission. Either this signal or the digital-to-analog converted (DAC) mapped digital video is selected for transmission. The tracking symbology is added onto the selected signal.

Secondly, the video signal is stripped of its sync, amplified and filtered (3 MHz) in a separate channel and applied to a 6 bit analog-to-digital converter (ADC) operating at a 6 MHz sampling rate. The output of the ADC is input to two gray level mapping circuits. These circuits, which operate under the control of the signal processor, map the 6 bit video (64 levels) into two 4 bit signals (16 levels each). One mapping circuit is associated with correlation tracking, the other with the autoboresight functions. The mapping is performed to allow all subsequent processing to be done at the 4 bit level thus decreasing the complexity of the circuitry.

3.1.2.5 Data compressor. The basic tracking scheme in PAMS relies on a 16 pixel by 16 pixel tracking gate and a 32 pixel by 32 pixel annulus around the gate which is the situation encountered with the smallest gate size. All other gate sizes require that the data be compressed into this format.

For ease of description, assume that N to 1 compression is required to achieve the 32 by 32 pixel format. Within a given line, N to 1 horizontal compression is achieved by adding the first N samples, dividing by N, storing the result in the pixel random access memory (RAM), zeroing the accumulator, and proceeding to the next set of N samples. When N lines have been horizontally compressed and stored in the pixel RAM, processing of new data is temporarily suspended. The pixel RAM addresses are modified to effect a 90° rotation, the horizontally compressed data are read from the pixel RAM and routed back through the data compressor to be compressed vertically and stored in the pixel RAM as horizontally and vertically compressed data.

3.1.2.6 Correlator. The correlator consists of various arithmetic logic elements, addressing logic and bus interface logic. It operates on data located in the pixel and reference RAMs. The pixel RAM data are arranged as a 32 by 32 matrix, the reference RAM data are arranged as a 16 by 16 matrix. The track processor outputs a starting row (IROW) and column (ICOL) address, and the correlator accumulates the value of the following expression and returns this value to the track processor:

$$\sum_{i=0}^{15} \sum_{j=0}^{15} \left| P_{(IROW + i),\ (\text{[illegible]} + j)} - R_{ij} \right|$$

where

P_{xy} = pixel RAM value at row X and column Y

R_{xy} = reference RAM value at row X and column Y.

In order to meet real-time requirements, the track processor executes a directed search which reduces the 256 possible calculations to 37. First, 25 correlation calculations are performed and the position of best match is determined to within a 4 by 4 pixel area. Then 12 additional calculations are performed as the best match position is located. An inter-pixel interpolation algorithm is executed by the track processor to yield target position to a higher degree of accuracy.

In addition to the correlation function just described, the correlator is used to calculate an auto-correlation of the data in the pixel RAM to determine that the target is indeed trackable. Also, the correlator logic copies the central 16 by 16 portion of the pixel RAM to the pixel copy RAM for use by the signal processor.

The pixel and reference RAMs are identical 1024 word memories whose functions switch back and forth. When the correlation calculation indicates that a new reference is required, the functions of the pixel and reference RAMs are reversed. In this manner an updated reference is always in memory for use if required.

3.1.2.7 Autoboresight. The autoboresight circuitry operates as an elementary video tracker. The digitized, mapped video is compared on a pixel by pixel basis to a threshold value (the assumption being that the boresight LED generates a bright spot), with the given pixel being assigned a value 1 if the threshold is exceeded and 0 otherwise. When 8 pixels have been examined, an 8 bit word representing 8 pixels is stored in the boresight RAM. This procedure is repeated until the central pixels have been processed. If the boresight switch on the control panel is activated, the signal processor accesses this data and calculates the centroid of the binary pattern. From this calculation X and Y error signals are devised, which are output to the autoboresight DACs which, in turn, shifts the center of the vidicon sweep pattern and thus corrects the LOS for boresight errors.

3.1.2.8 Pixel copy RAM. The pixel copy RAM contains the central 16 by 16 area of the mapped, compressed video data from the pixel RAM. Data are written into the pixel copy RAM by the correlator. Its contents are accessed by the signal processor and used in a variety of calculations.

The average value of the central 4 pixels are used as a measure of scene brightness. This value is used to control the gray level mappers. Data from the corner pixels determines the background level. Background level and scene brightness are used to determine the threshold value to be used in the centroid calculations. Also, if the target intensity is less than that of the background, the data are processed as inverse video.

A histogrammer is included in the PAMS hardware in an attempt to provide a more sophisticated method of target/background separation. However, this method of separation did not provide a significant increase in performance over the much simpler method of sampling the center and corners, and thus, it was not used in the final software.

The entire contents of the pixel copy RAM are used to calculate the target centroid, defined by

$$X = \frac{\sum_{ij} A_{ij} * i}{\sum_{ij} A_{ij}} \qquad Y = \frac{\sum_{ij} A_{ij} * j}{\sum_{ij} A_{ij}}$$

where

$$A_{ij} = \begin{cases} P_{ij} - T & \text{if } P_{ij} - T \geq 0 \\ \phi & \text{if } P_{ij} - T < 0 \end{cases}$$

P_{ij} = pixel value at row i, column j

T = threshold valve

i = row

j = column

$$\sum_{ij} = \sum_{i=0}^{15} \sum_{j=0}^{15}.$$

The target position from this calculation is made available to the track processor.

The pixel copy RAM data are also used to determine target size. When the system is operating in centroid track mode this size information is used to automatically control the gate size.

3.2 PAMS ANGLE MEASUREMENT ACCURACY

3.2.1 Purpose

Tests were performed to determine whether PAMS meets its accuracy specifications of ±1 mrad (rms) in azimuth and elevation. The miss distance indicator (MIDI) and the MP-36, which are ground-based instrumentation radar tracking systems with specified tracking accuracies of ±1 mrad, were used as the standard of comparison during the dynamic angle measurement accuracy test.

3.2.2 Method

PAMS was placed at a surveyed location and leveled. To obtain dynamic accuracy data, both PAMS and either MIDI or the MP-36 were locked onto a maneuvering aircraft, and target position from both PAMS and the radar were recorded. Static accuracy data were obtained by sequentially locking PAMS onto five surveyed targets and recording the indicated azimuth angle.

3.2.3 Analysis

3.2.3.1 Dynamic accuracy. The MIDI data were subjected to a coordinate transformation which translated the origin and rotated the axes such that the PAMS and MIDI data were in coincident coordinate systems. Data from both systems were interpolated to yield identical time data. The PAMS data were

3.2.3.1 (Cont'd)

subtracted from the MIDI data and the mean and standard deviation of these differences calculated. The results from several passes are presented in table 3-3. This table is based on unsmoothed target position data with the range to the target varying from 250 meters to 12 km.

TABLE 3-3. COMPARISON BETWEEN RAW MIDI AND PAMS TARGET POSITION DATA

	Azimuth (mrad)		Elevation (mrad)	
Pass No.	Mean Difference	Standard Deviation	Mean Difference	Standard Deviation
1342	-1.50	3.86	-0.32	1.73
1343	1.57	5.45	0.081	2.87
1344	-1.34	2.25	0.004	1.02
1345	3.77	6.01	-0.05	3.25
1346	-2.31	6.40	-0.86	2.77
1347	1.67	6.62	0.48	2.72
1349	2.83	4.00	0.32	1.96
1350	0.94	3.91	0.48	2.57
1351	-2.87	8.58	-1.13	2.76
1352	3.01	8.31	-2.17	5.65
1353	-1.53	4.94	-1.42	2.54

This table gives the indication that PAMS tracking accuracies are on the order of 5 and 3 mrad in azimuth and elevation respectively. An examination of the MIDI data, as shown along with PAMS tracking data in figures 3-9 through 3-12, points out that the MIDI data are subject to noise. To counteract this noise the MIDI data were processed through a polynominal smoothing routine for further examination.

3.2.3.1 (Cont'd)

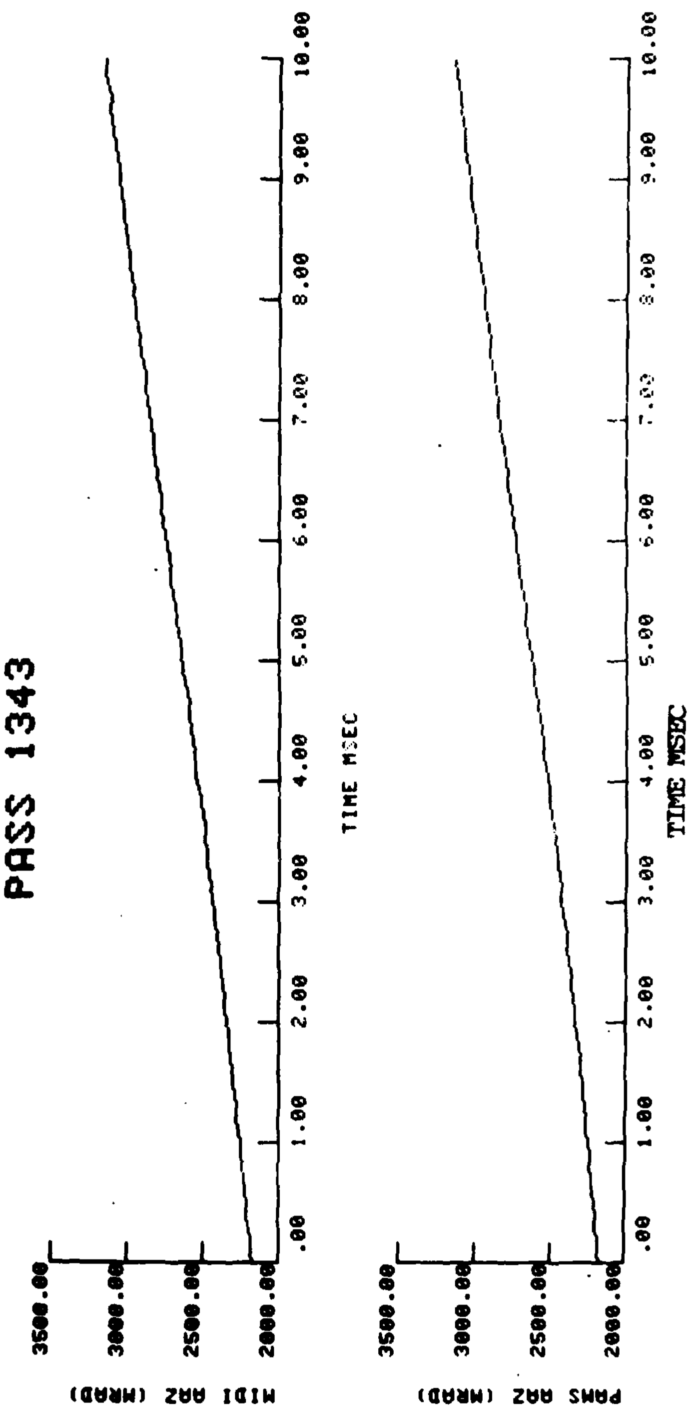


Figure 3-9. DIVADS target elevation position, MIDI and PAMS measurement.

3.2.3.1 (Cont'd)

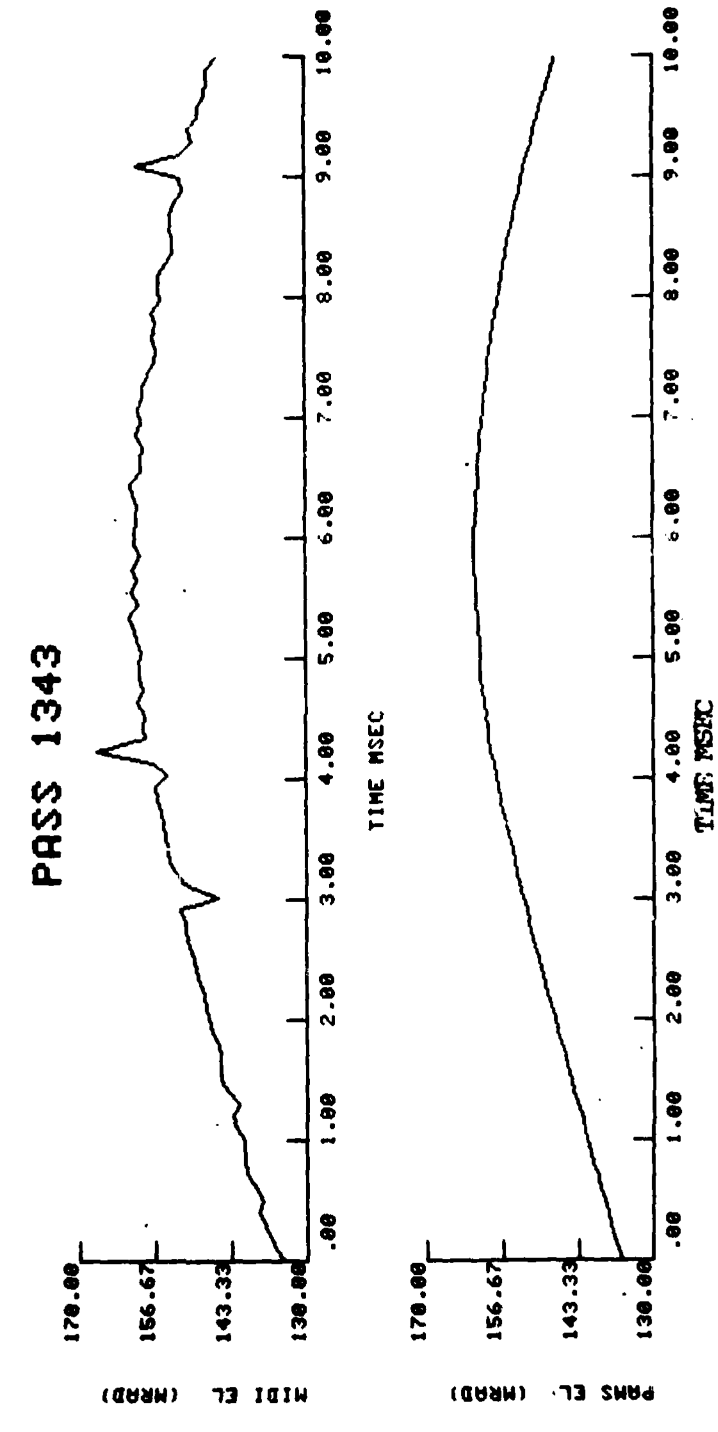


Figure 3-10. DIVADS target azimuth position, MIDI and PAMS measurement.

3.2.3.1 (Cont'd)

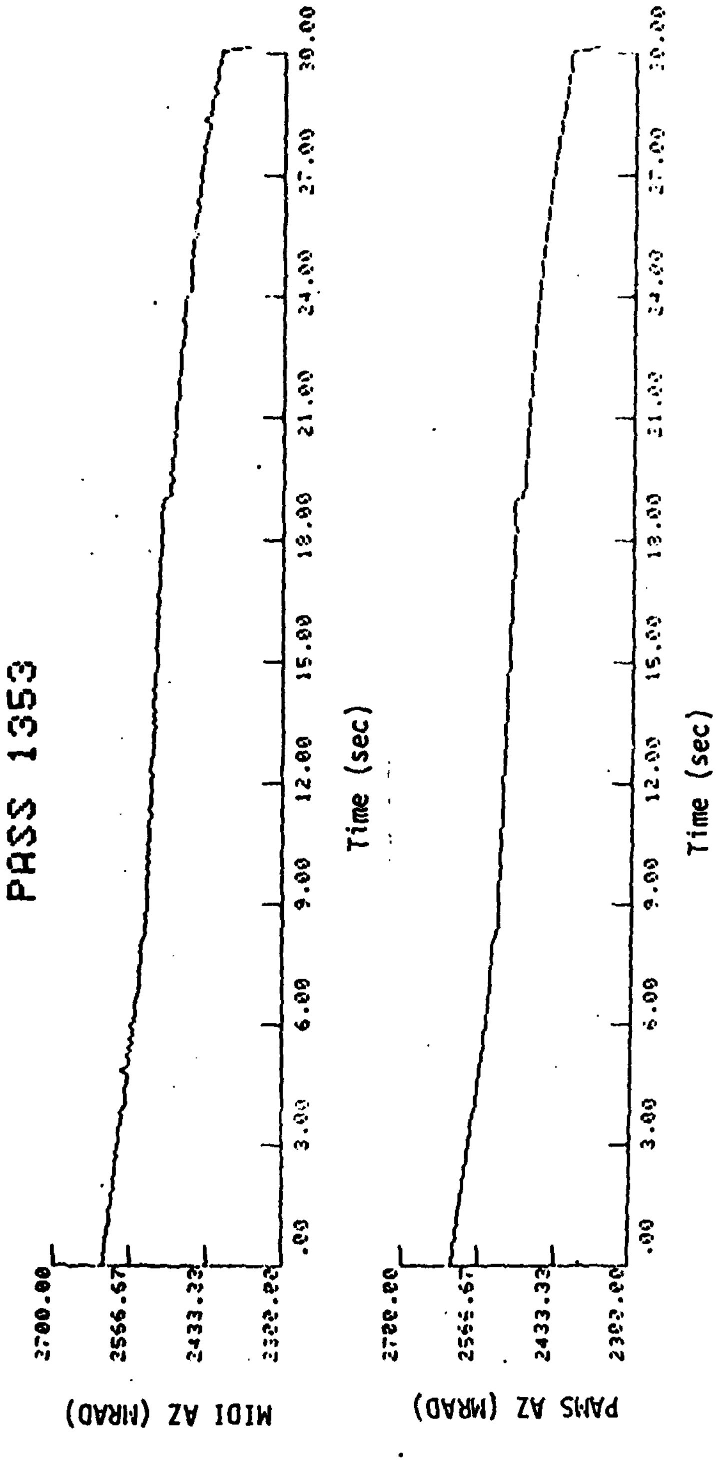


Figure 3-11. DIVADS target azimuth position, MIDI and PAMS measurement.

3.2.3.1 (Cont'd)

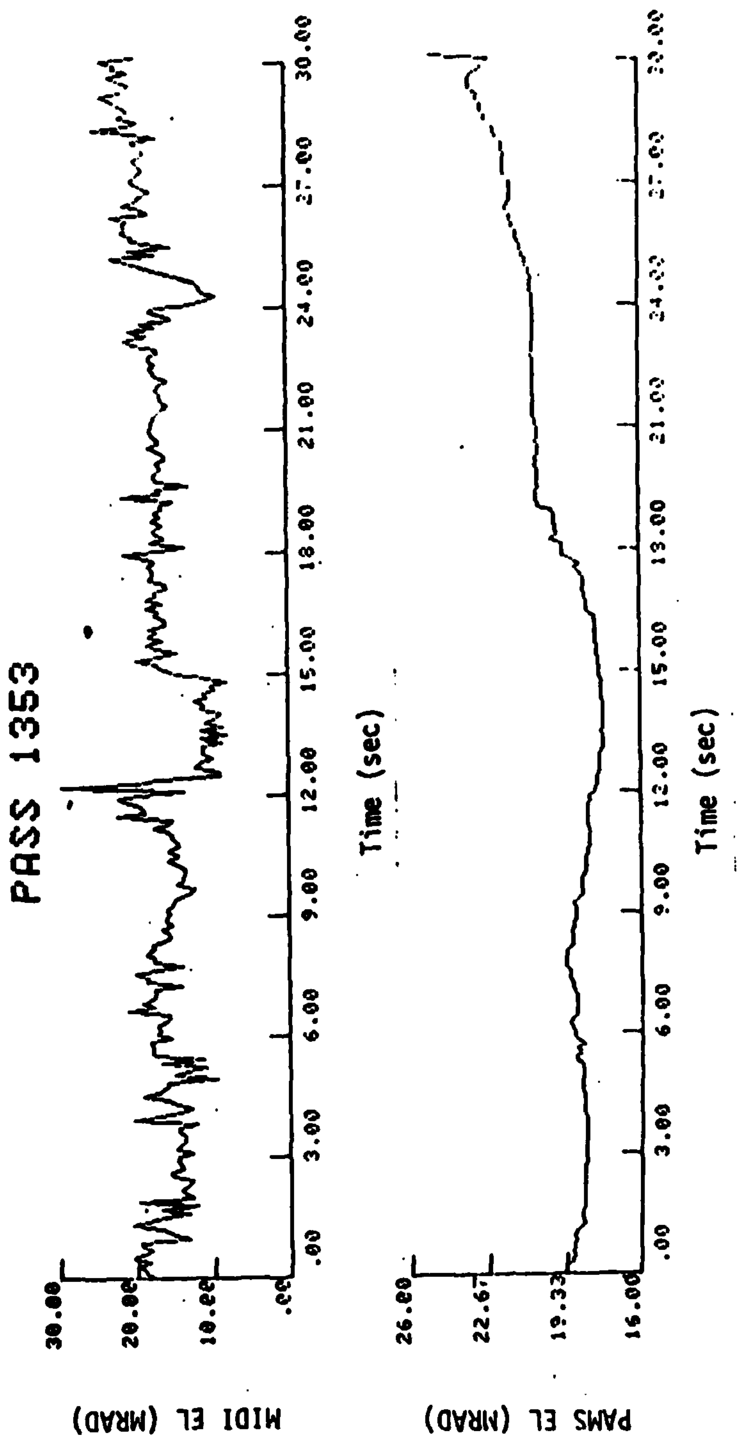


Figure 3-12. DIVADS target elevation position, MIDI and PAMS measurement.

3.2.3.1 (Cont'd)

Another area which could lead to differences between PAMS and MIDI is accentuated by table 3-4 which gives the milliradian size of an A-7 jet aircraft as a function of range. The large target size at close ranges makes track point definition difficult. To separate this potential difference, data were analyzed in range segments. Typical results of this analysis are given in table 3-5.

TABLE 3-4. TARGET SIZE AS A FUNCTION OF RANGE

Range (m)	Wingspan (mrad)	Length (mrad)	Height (mrad)
250.	67.0561	64.0081	12.8016
1000.	16.7640	16.0020	3.2004
2000.	8.3820	8.0010	1.6002
3000.	5.5880	5.3340	1.0668
4000.	4.1910	4.0005	0.8001
5000	3.3528	3.2004	0.6401

TABLE 3-5. COMPARISON BETWEEN SMOOTHED MIDI AND PAMS TARGET POSITION DATA BY RANGE

Pass No.	Approx Range (km)	Azimuth (mrad) Mean Difference	Azimuth (mrad) Standard Deviation	Elevation (mrad) Mean Difference	Elevation (mrad) Standard Deviation
1342	>4	-0.45	0.53	-0.16	0.13
	<4	-3.91	1.77	-0.34	0.26
1343	>4	-1.81	0.85	0.43	1.31
	<4	5.64	3.15	-0.63	0.71
1344	>4	-0.57	0.41	-0.10	0.11
	<4	-3.23	0.77	0.09	0.11
1345	>4	0.60	0.53	1.10	0.79
	<4	9.93	3.86	-2.12	2.29
1346	>4	-0.02	0.64	-0.24	0.15
	<4	-6.29	4.71	-1.00	1.27
1347	>4	-1.69	0.62	1.39	0.20
	<4	9.58	4.96	-0.93	2.41
1349	>4	3.05	3.57	0.32	1.09
	<4	4.99	0.09	-0.78	0.06
1350	>4	-1.96	0.77	2.05	0.40
	<4	4.52	0.69	-1.60	1.52
1351	>4	-0.91	3.29	-1.78	2.50
	<4	-1.19	3.31	-1.14	0.72
1352	>4	3.59	8.47	-2.12	5.91
	<4	3.35	4.80	-1.95	2.71
1353	>4	-0.30	1.77	-1.49	0.51
	<4	-7.47	1.17	-1.34	0.07

3.2.3.1 (Cont'd)

Consideration of passes 1342 to 1346 indicates that PAMS is within the ±1 mrad accuracy requirement on a sufficiently well-defined target, whereas passes 1347 to 1353 give the indication that the tracking accuracy tolerance is larger. An examination of the time histories for these latter passes, however, shows an inordinate amount of tracking noise in the MIDI data. These passes were conducted at lower elevation angles which accounts for the higher noise level and effectively makes the MIDI data unusable. Throughout all of these passes, PAMS maintained a smooth track, indicative of the target motion, leading to the contention that PAMS does meet the accuracy requirement and that deviations between PAMS and MIDI are due primarily to track point differences and MIDI tracking errors.

In addition to the test just described, data were acquired with PAMS mounted on a stationary DIVAD turret and an MPS-36 radar tracking an SH-3 helicopter. As before, coordinate transformations and time interpolation were performed to allow comparison to be made. Figures 3-13 and 3-14 show the differences between PAMS and the radar in azimuth and elevation, respectively, for one representative pass (1802). In these passes, the target was in-bound at near zero azimuth, with the range decreasing (target size increasing) with increasing time, which is indicated by the increasing difference between PAMS and the MPS-36 radar. Figures 3-15 through 3-18 are plots of the composite differences and the standard deviations of these differences in azimuth and elevation for five similar passes, including the pass plotted in figures 3-13 and 3-14. These plots demonstrate the correlation between PAMS and the radar, and also show a large difference at close range which is attributable to track point differences.

The data presented here indicate that PAMS tracking accuracy is on the order of the ±1 mrad, but it must be pointed out that these tests used only two targets and only a small portion of the space over which PAMS is required to function. Further testing is indicated, and it is planned that such testing will be performed during the range check out phase of the next test of the SGT York (summer 83). During this testing the Aided Laser Tracking System will hopefully be available. In addition, it is anticipated that extensive testing of PAMS will be performed in the moving target simulator when that facility becomes available.

3.2.3.1 (Cont'd)

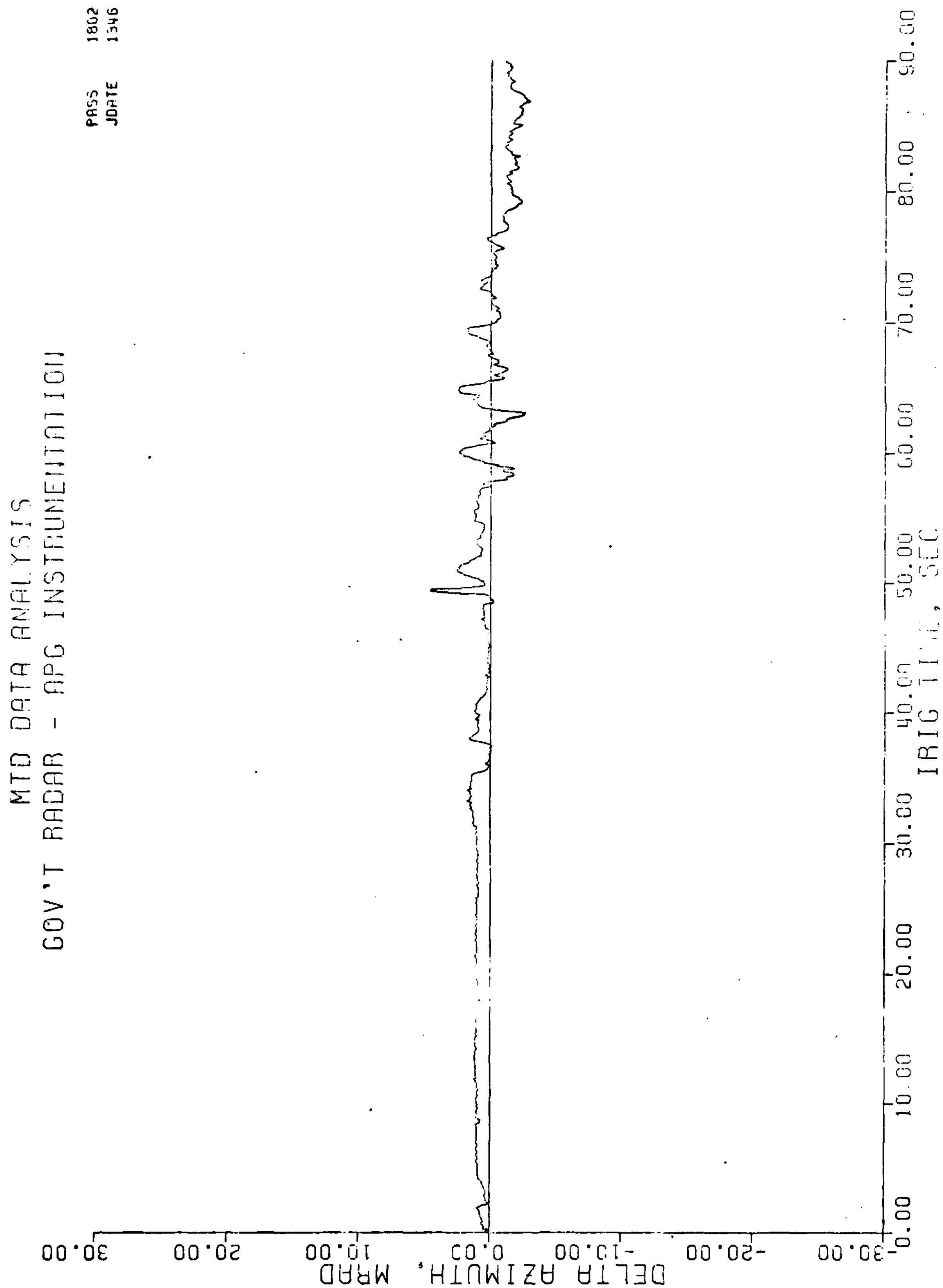


Figure 3-13. Government radar - APG instrumentation.

3.2.3.1 (Cont'd)

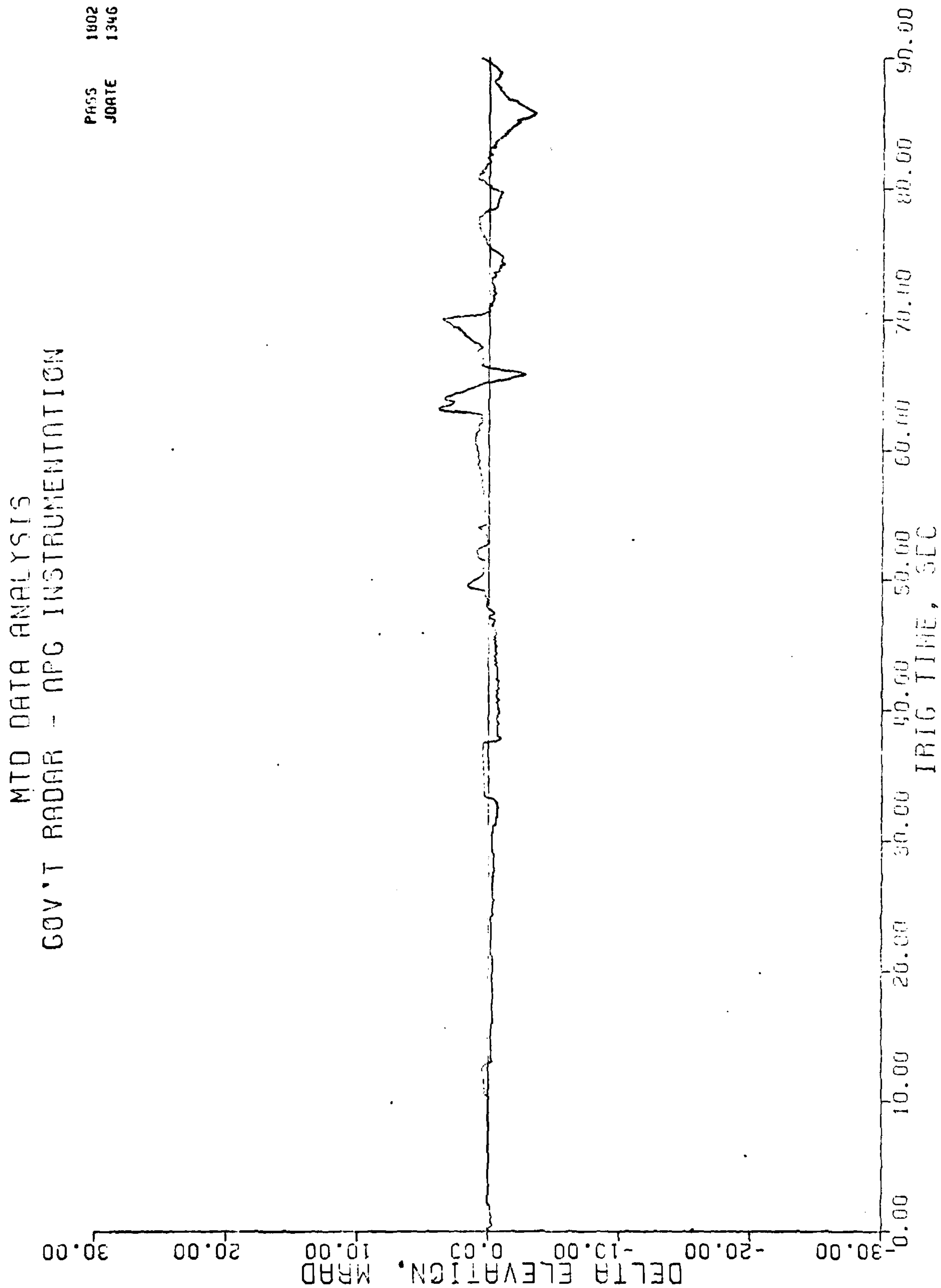


Figure 3-14. Government radar - APG instrumentation.

3.2.3.1 (Cont'd)

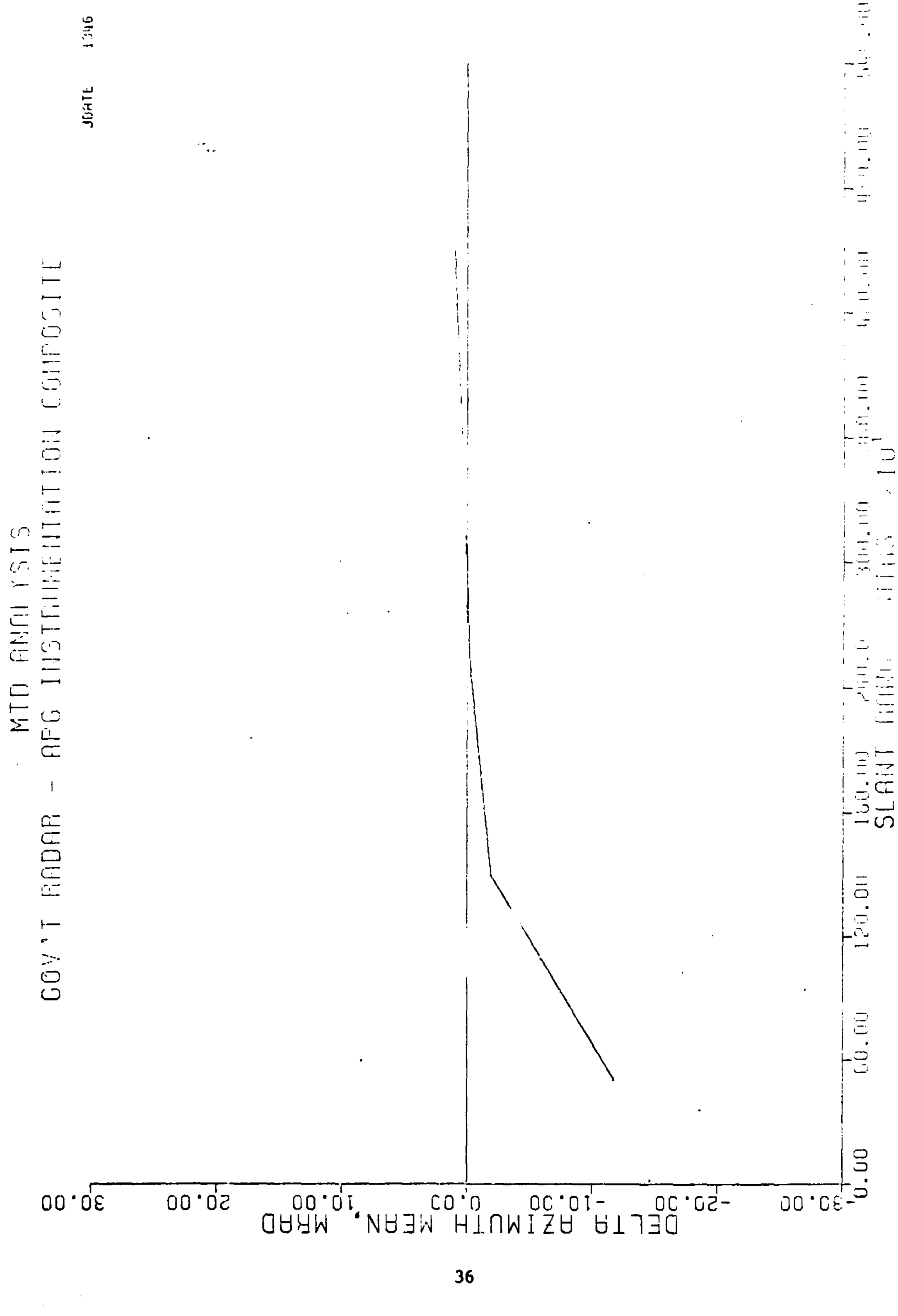


Figure 3-15. Government radar - APG instrumentation composite.

3.2.3.1 (Cont'd)

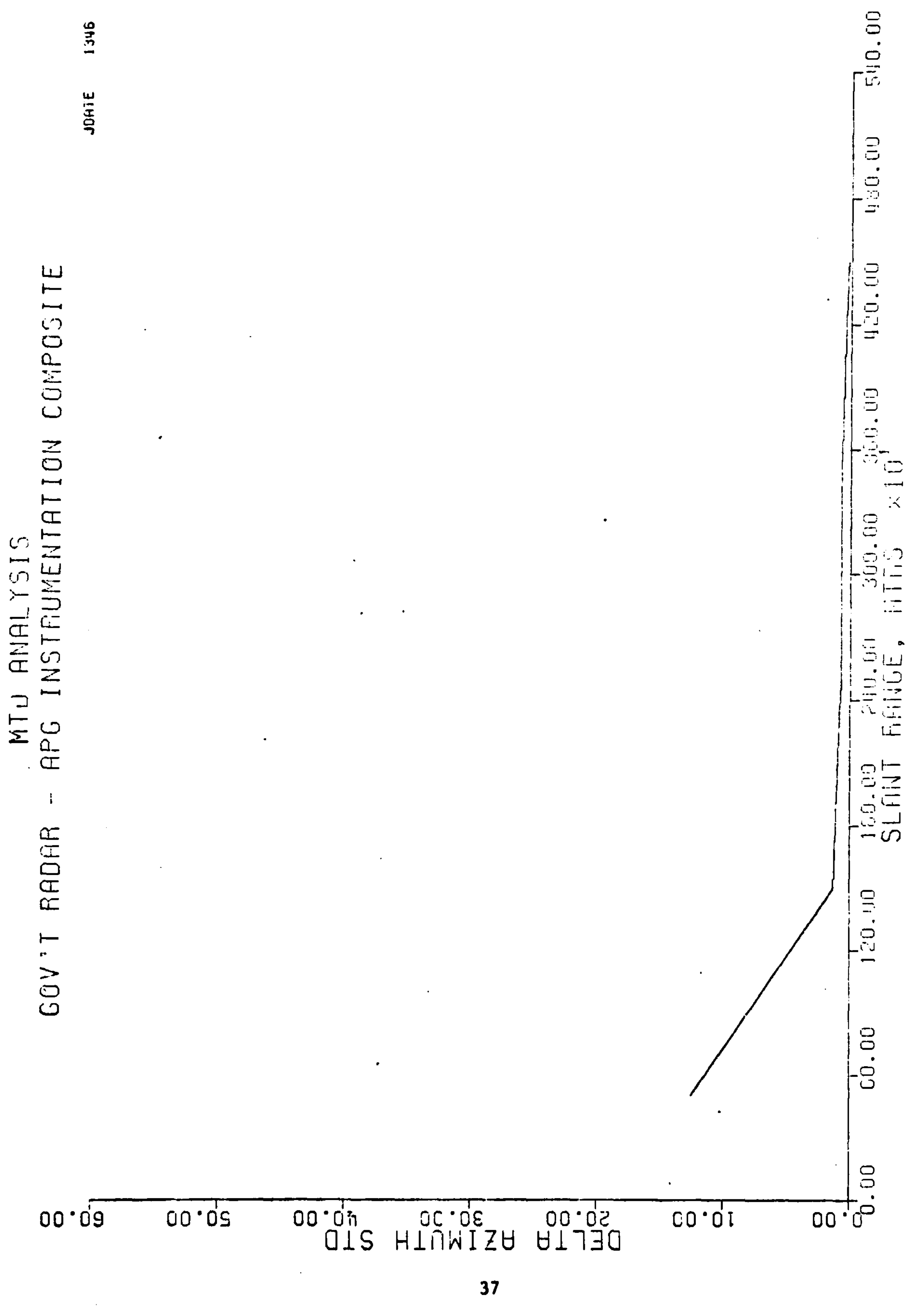


Figure 3-16. Government radar - APG instrumentation composite.

3.2.3.1 (Cont'd)

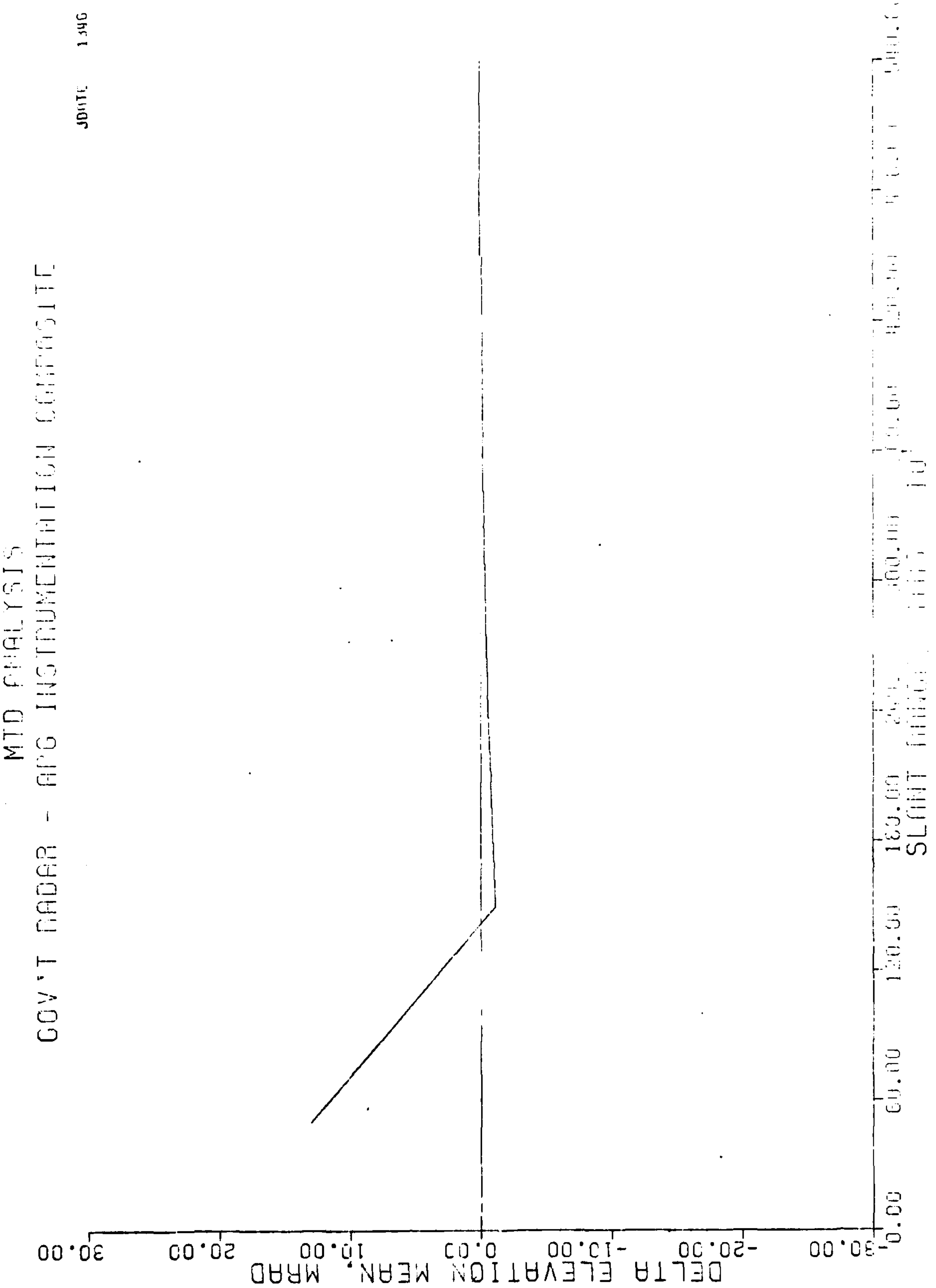


Figure 3-17. Government radar - APG instrumentation composite.

3.2.3.1 (Cont'd)

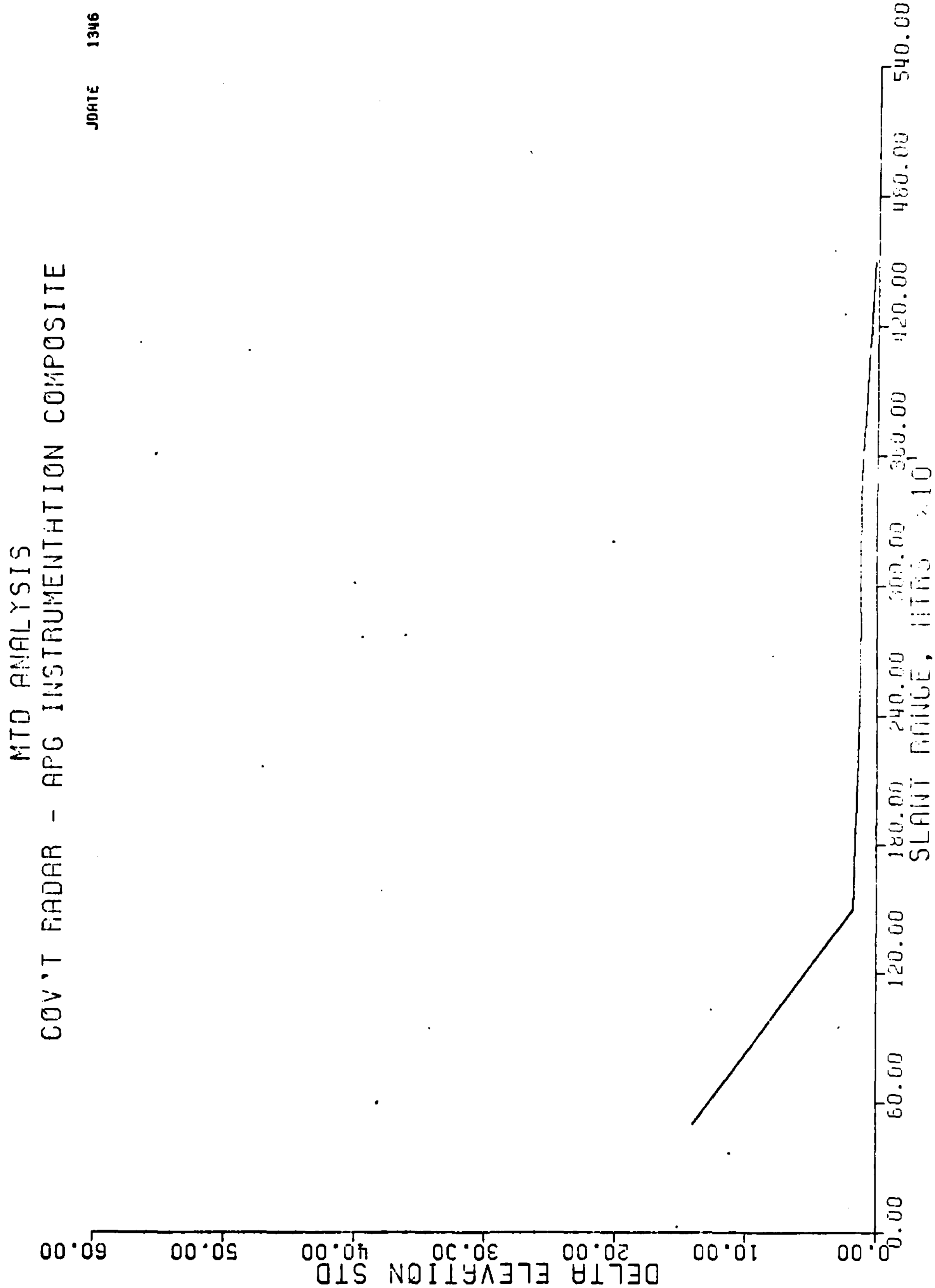


Figure 3-18. Government radar - APG instrumentation composite.

3.2.3.2 <u>Static accuracy</u>. Presented in table 3-6 are data from the two static accuracy tests that were performed. The bias, between the PAMS data (due to different, arbitrary reference points) and the survey data was removed using a linear curve fit procedure with the multiplicative term constrained to be unity. The RMS difference between PAMS and the survey data is 1.10 mrad for the first test. The corresponding RMS error for the second test was 1.01 mrad. The RMS error calculated for the angles between adjacent targets as determined from PAMS when compared to the survey data was 1.18 mrad using all data. The maximum difference between PAMS and survey data was 1.8 mrad.

From these data, the conclusion can be drawn that PAMS' RMS errors are on the order of 1 mrad. However, the data base is not sufficiently broad that such conclusions may be treated as other than tentative. Also, it should be noted that these tests are concerned only with azimuth.

An examination of table 3-6 indicates that PAMS' readings are highly repeatable. This suggests that performance could be enhanced by the use of a non-linear mapping of PAMS' output to azimuth and elevation. At this time, however, insufficient data are available to provide validity to this approach.

TABLE 3-6. STATIC AZIMUTH POINTING DATA
(Readings in mRad)

Target/ Trial	1	2	3	Survey
		Test 1		
1	-1507.0	-1507.2	-1507.2	3040.7
2	-1060.8	-1060.7	-1060.6	2593.4
3	- 623.5	- 623.5	- 623.5	2155.6
4	204.2	204.4	+ 204.5	1325.7
5	1247.5	1247.5	1247.5	284.2

Target/ Trial	1	2	3	4	Survey
			Test 2		
1	-1428.8	-1428.9	-1428.7	-1428.7	3406.2
2	- 966.3	- 965.9	- 965.9	- 966.0	2585.2
3	- 519.7	- 519.8	- 5[illegible]	- 519.8	2140.1
4	313.8	313.8	313.9	313.7	1305.4
5			Not Recorded		

3.3 SYSTEM INTEGRATION AND INTERFACE

PAMS has been instrumental in both the design test/operations test (DT/OT) of Division Air Defense System (DIVADS) and the DIVADS check test. Reference 2 gives a complete description of the DIVADS instrumentation. Shown in figure 3-19 is a drawing showing the location of the vehicle mounted instrumentation as configured for the DIVADS check test. This instrumentation consists of:

a. PAMS sensor.

b. Vertical gyro.

c. Gun camera.

d. Muzzle velocity radar (MVR).

e. Data acquisition module.

Figure 3-20 is a photograph of the PAMS sensor/turret mounted on the DIVADS fire unit.

PAMS was mounted to the DIVADS fire unit using a specially prepared mount with locking jack screws for pitch and roll adjustment and a locking, pivoting plate for azimuth adjustment (fig. 3-21). The vehicle was placed on jacks and positioned such that a V-scope attached to the DIVADS "true point" was centered on a downrange calibration target. PAMS was rotated in azimuth and adjusted in elevation so that it was also centered on the target. At this point, PAMS was alined in pitch and yaw. To achieve alinement in roll, the DIVADS turret was rotated approximately 90° to the right while PAMS remained locked onto the target. PAMS elevation was recorded, as was the turret pitch and roll. The turret was then rotated approximately 180° to the left where PAMS elevation and turret pitch and roll were recorded. The turret attitude in the direction of the target in each instance was calculated, and the PAMS elevation readings adjusted by this figure. The difference between the two adjusted readings was the approximate roll orientation of PAMS relative to the turret. The roll adjusting jack screws were adjusted accordingly. The alinement process starting with pitch and yaw was iterated until all three axes were alined.

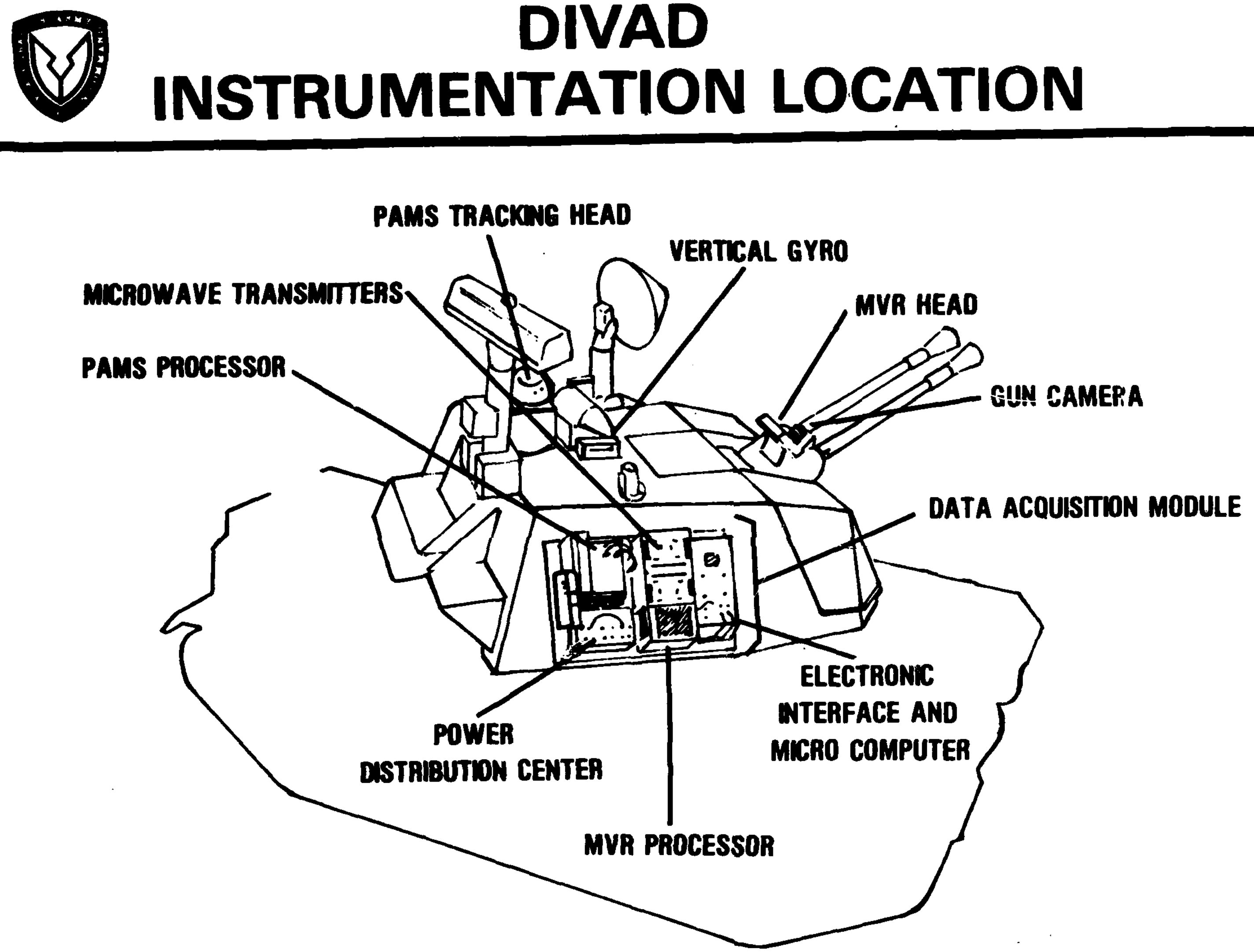


Figure 3-19. Instrumentation locations for DIVADS.

3.3 (Cont'd)

Figure 3-20. PAMS tracking head mounted on DIVADS.

3.3 (Cont'd)

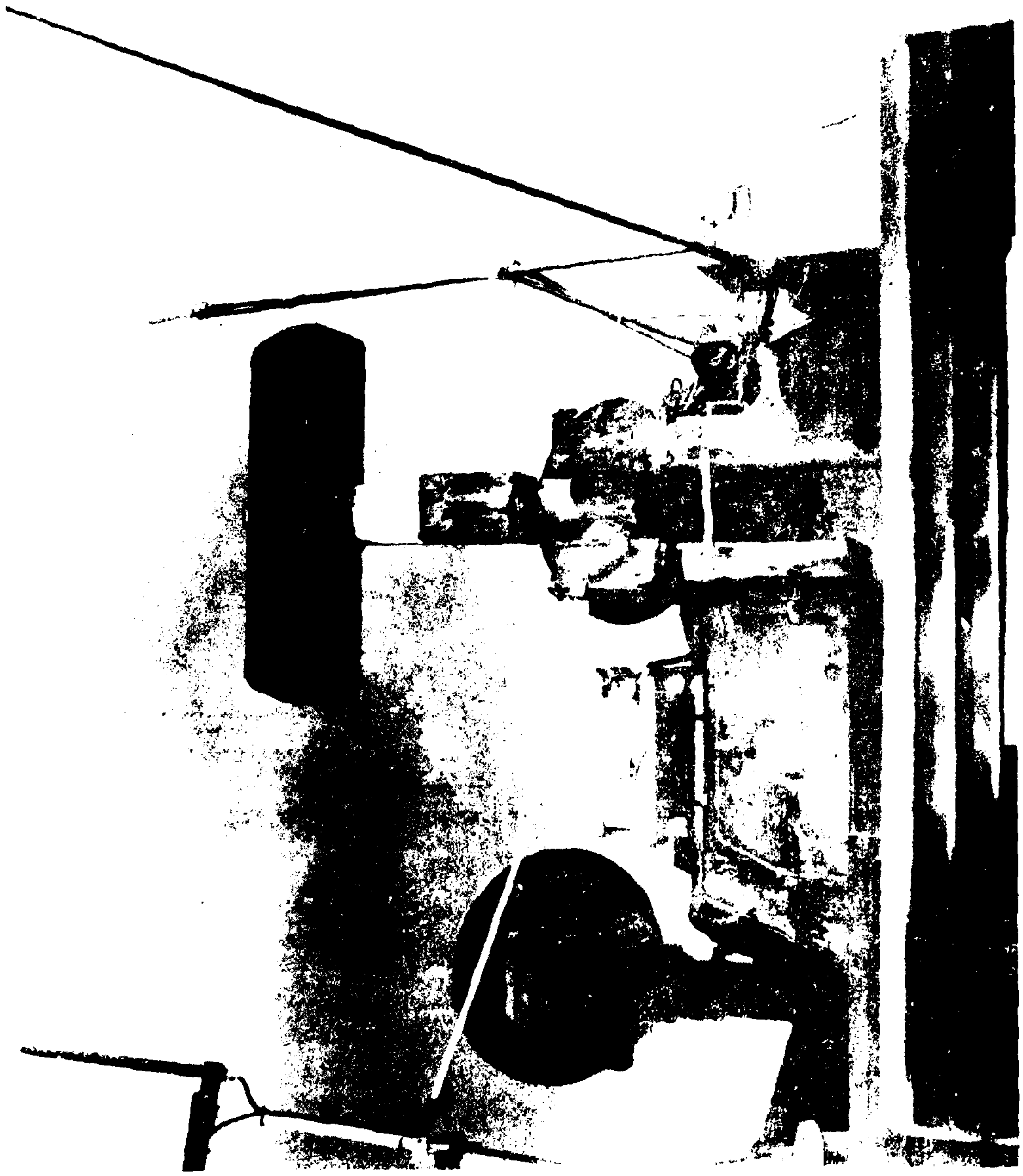


Figure 3-21. PAMS on mounting bracket.

3.3 (Cont'd)

Figure 3-22 is a photograph of the data acquisition module containing most of the ancillary instrumentation for the DIVADS test. A block diagram of the overall on-board instrumentation system is depicted in figure 3-23.

The instrumentation interface block diagram is shown in figure 3-24. This unit, based on an STD-BUS 8085 microcomputer, performs the following functions:

a. Acquires pointing angle data from PAMS.

b. Acquires system data from the DIVADS 1553 data bus.

c. Acquires data from the vertical gyro and muzzle velocity radar.

d. Separates PAMS and interface commands and decodes the interface commands.

e. Based on input commands, performs appropriate coordinate conversions and outputs acquisition angles to PAMS.

f. Formats all data into a serial PCM data stream for transmission to the data acquisition facility.

PAMS angles are input to the microcomputer through a digital input subsystem, as are the outputs of the interface command circuit and the 1553 bus interface circuit. PAMS acquisition angles are output through a digital output subsystem.

The input commands direct the interface to use DIVADS radar, sight, or gun pointing angles, or zero as PAMS acquisition reference. Coordinate transformations are necessary because the sight is an elevation first gimbal system, whereas azimuth first, coordinates are required. In order to provide real-time performance, the converted coordinates are stored in a two-way look-up table. The conversion algorithm is based on a look-up and two dimensional interpolation technique. The system radar angles are in the appropriate coordinate system, but these data are floating point numbers that must be converted to natural units. To enhance the speed performance of these real-time conversion algorithms, and 8X8 multiplier periferial was developed to enable multiplications to be performed in submicrosecond time intervals.

3.3 (Cont'd)

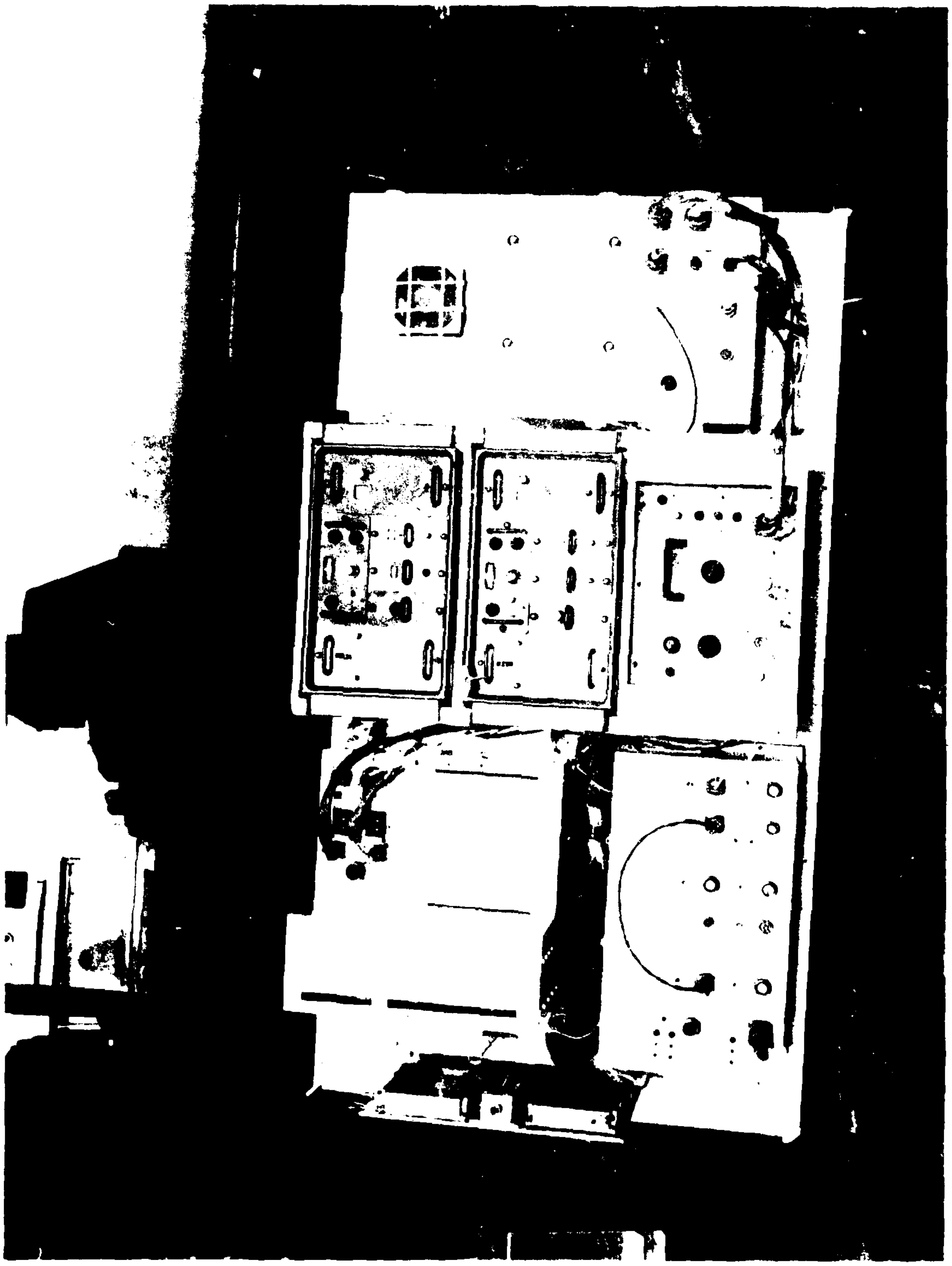


Figure 3-22. DIVADS check test instrumentation.

3.3 (Cont'd)

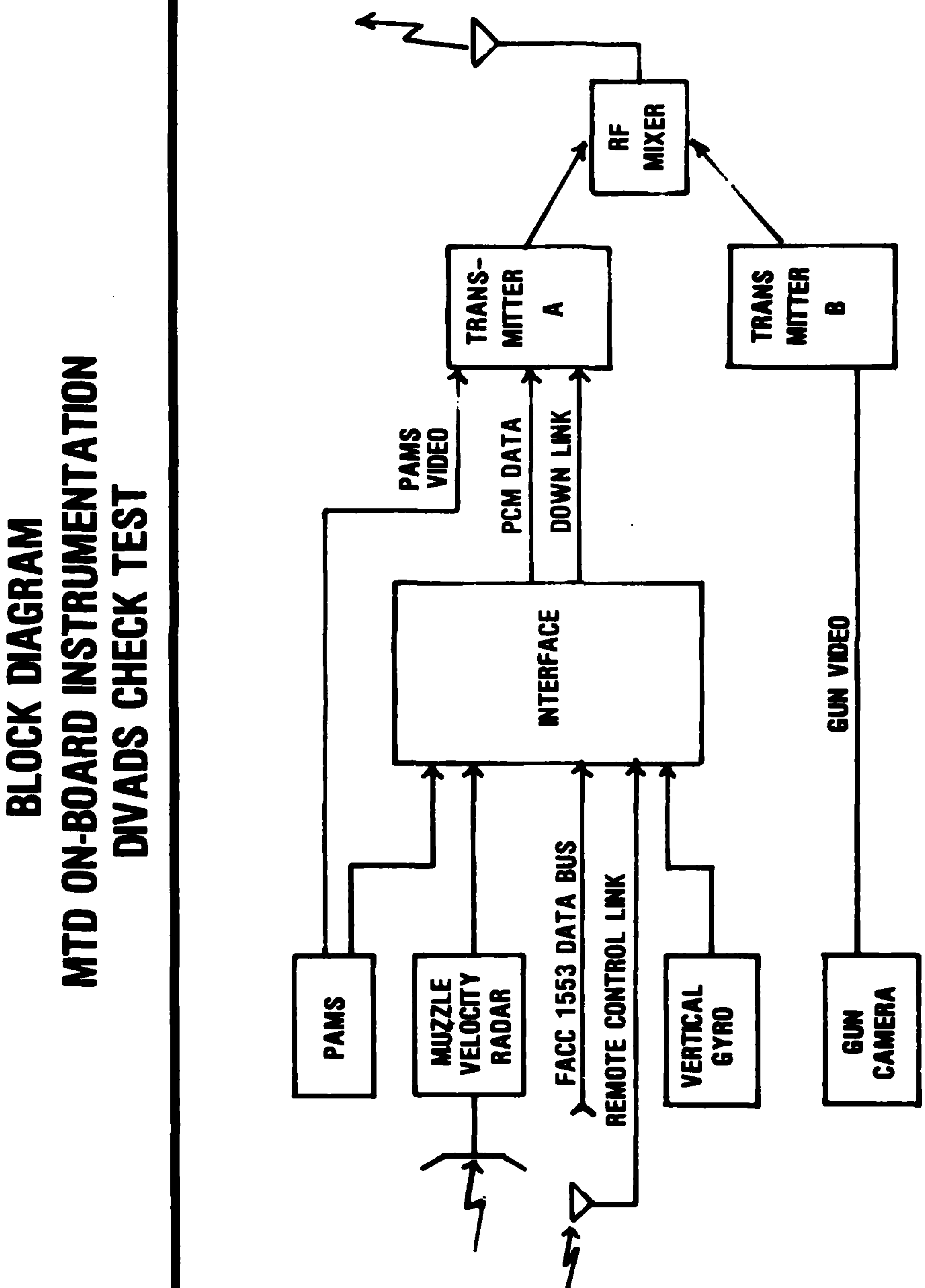


Figure 3-23. Block diagram of DIVADS instrumentation.

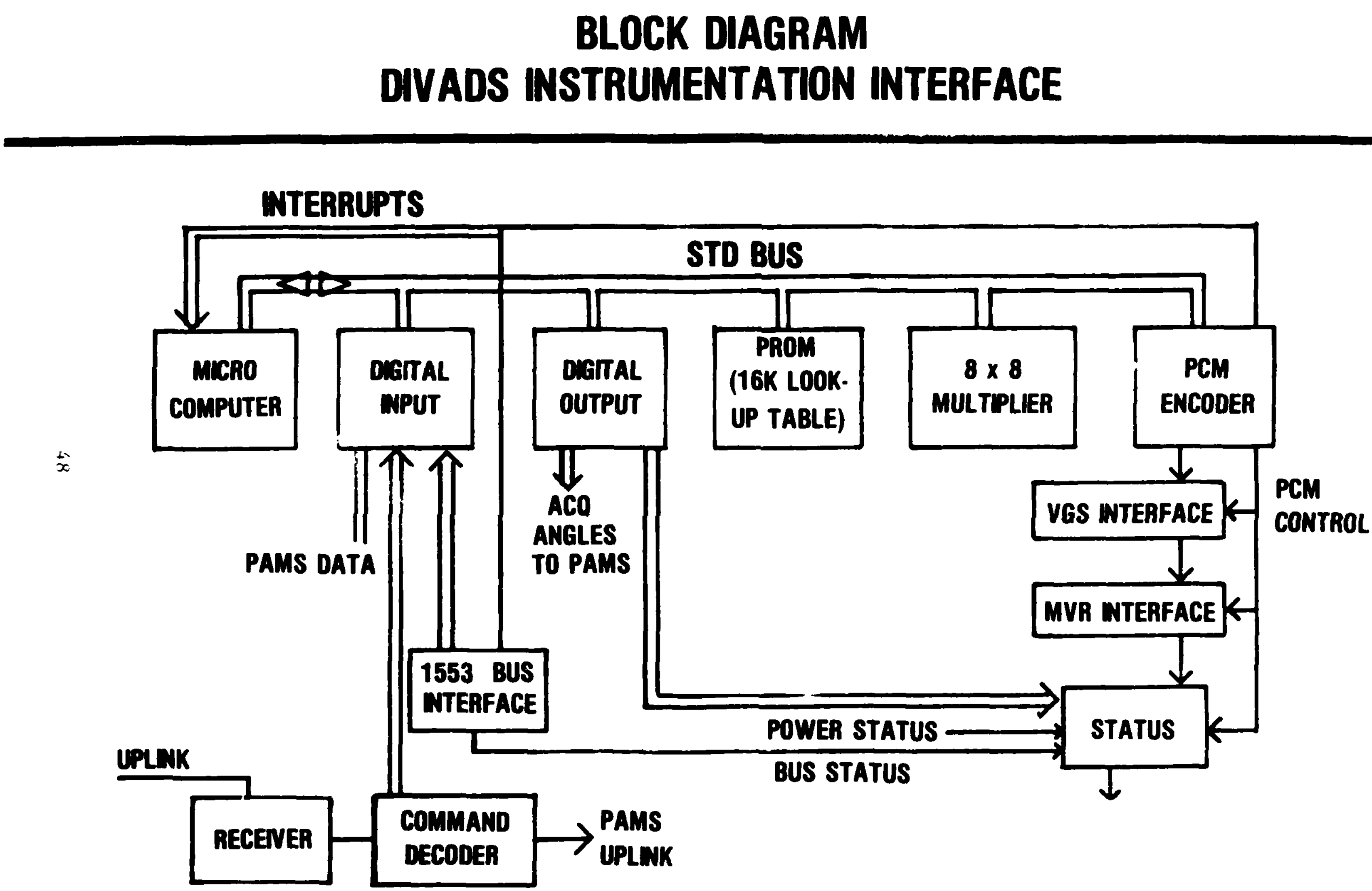


Figure 3-24. Block diagram of DIVADS instrumentation interface.

3.3 (Cont'd)

A more detailed look at the 1553 bus interface is shown in figure 3-25. This circuit functions as a bus monitor and word selector. Word selection is performed at this level because the amount of bus traffic would overload the processor if the hardware did not reject all data not desired. (DIVADS loading consists of 15,475 words/sec, with burst rates to 50,000 words/sec). In this unit, the level 1 PROM is programmed to either reject an entire block of data, or to generate a partial address for level 2 PROM. The remainder of level 2 PROM's address is the word count within the block, so that specific words from specific blocks can be selected for recording. Level 2 PROM generates signals required for recording as well as an address vector to direct the storage of the data. For the test, 62 system data channels were recorded.

The Pulse Code Modulation (PCM) encoder, an in-house developed subsystem, is shown in figure 3-26. This subsystem is configured as an STD-BUS periferial device. In this encoder, a complete frame of data is loaded into the first-in first-out (FIFO) memory. The bit rate and frame length are under program control. The output is compatible with APG's telemetry test site terminals. The outputs of this subsystem are the serial PCM data stream, a register load signal, and synchronous clock.

The vertical gyro, muzzle velocity radar, and interface status are each configured with a 16 bit parallel-to-serial converter at its output. With this configuration the serial data stream can be input to the first subsystem. The output serial stream of the first subsystem is then input to the next subsystem and so on, with the load and synchronous clock controlling the parallel-to-serial converters. In this way interconnecting wiring, which is a potential failure point, is held to a minimum.

Figure 3-27 is a block diagram of the telemetry test site terminal utilized during the DIVADS check test. The terminal is a standard APG data acquisition system as shown in figures 3-28, 3-29, and 3-30 and described in detail in reference 1.

The PCM serial data stream received from the on-board instrumentation is converted to parallel data, merged with PAMS status and during premission and postmission alinement checks, with target azimuth and elevation data from the gun camera video tracker. The data stream is spooled to disk in real time, which serves as the primary storage medium.

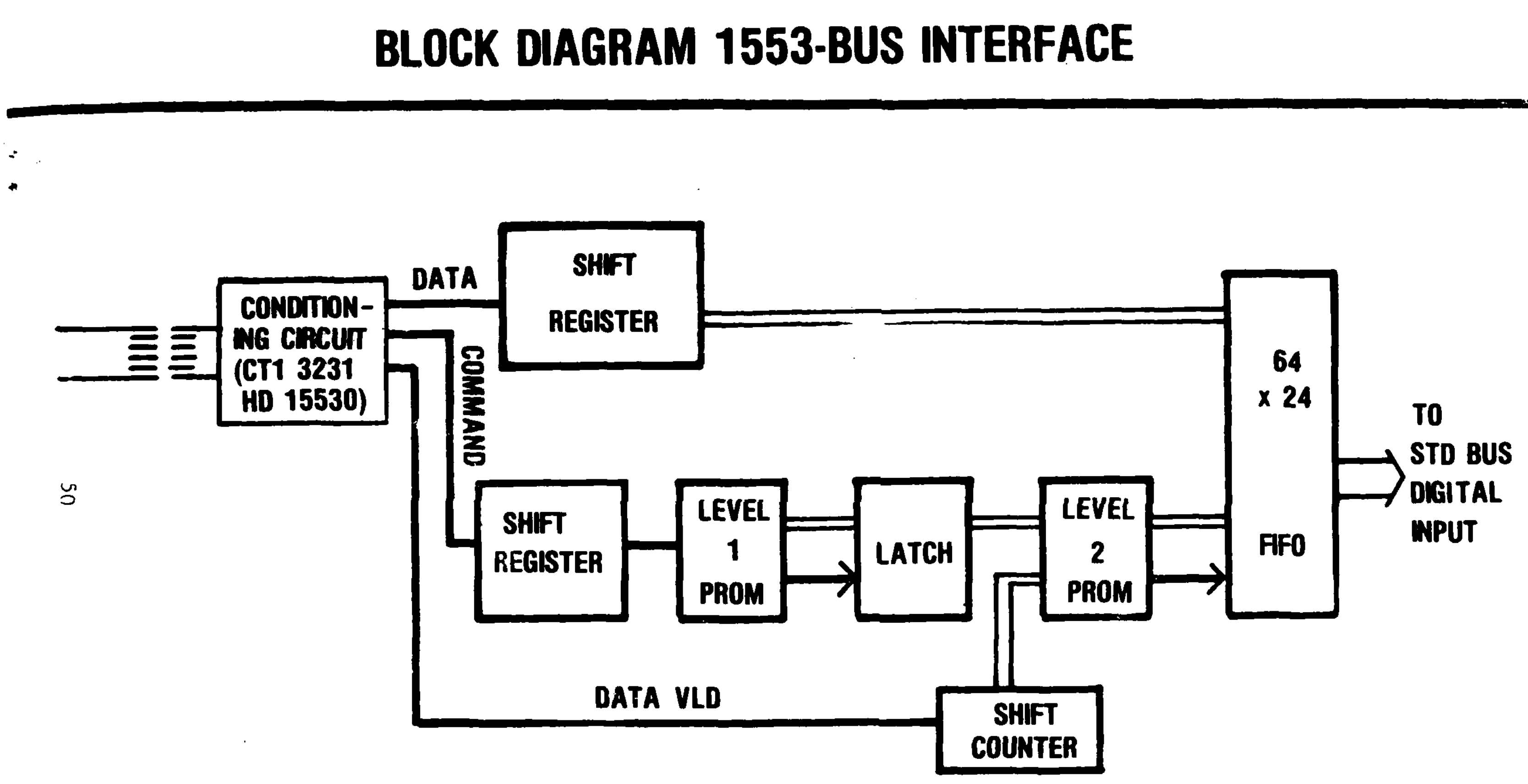


Figure 3-25. 1553-Bus interface on DIVADS instrumentation interface.

3.3 (Cont'd)

BLOCK DIAGRAM PCM ENCODER

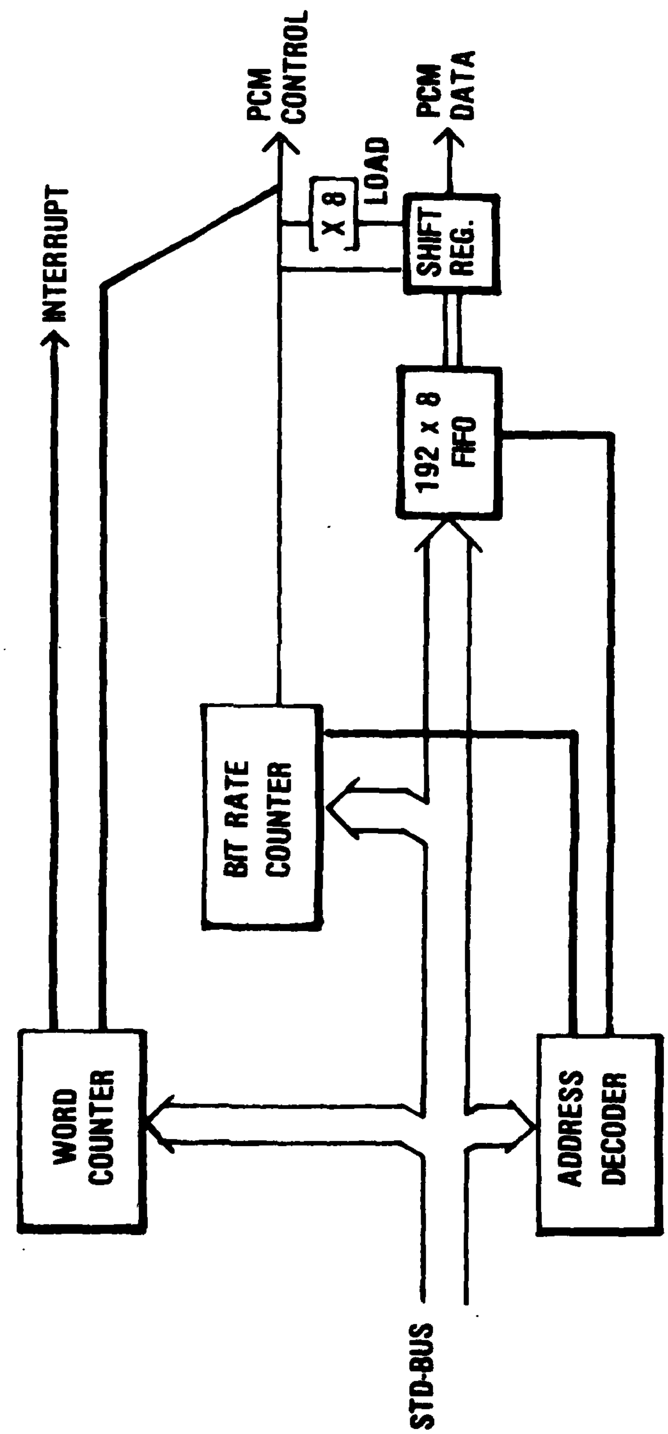


Figure 3-26. PCM encoder for DIVADS instrumentation interface.

BLOCK DIAGRAM
MTD TELEMETRY TEST SITE TERMINAL
DIVADS CHECK TEST

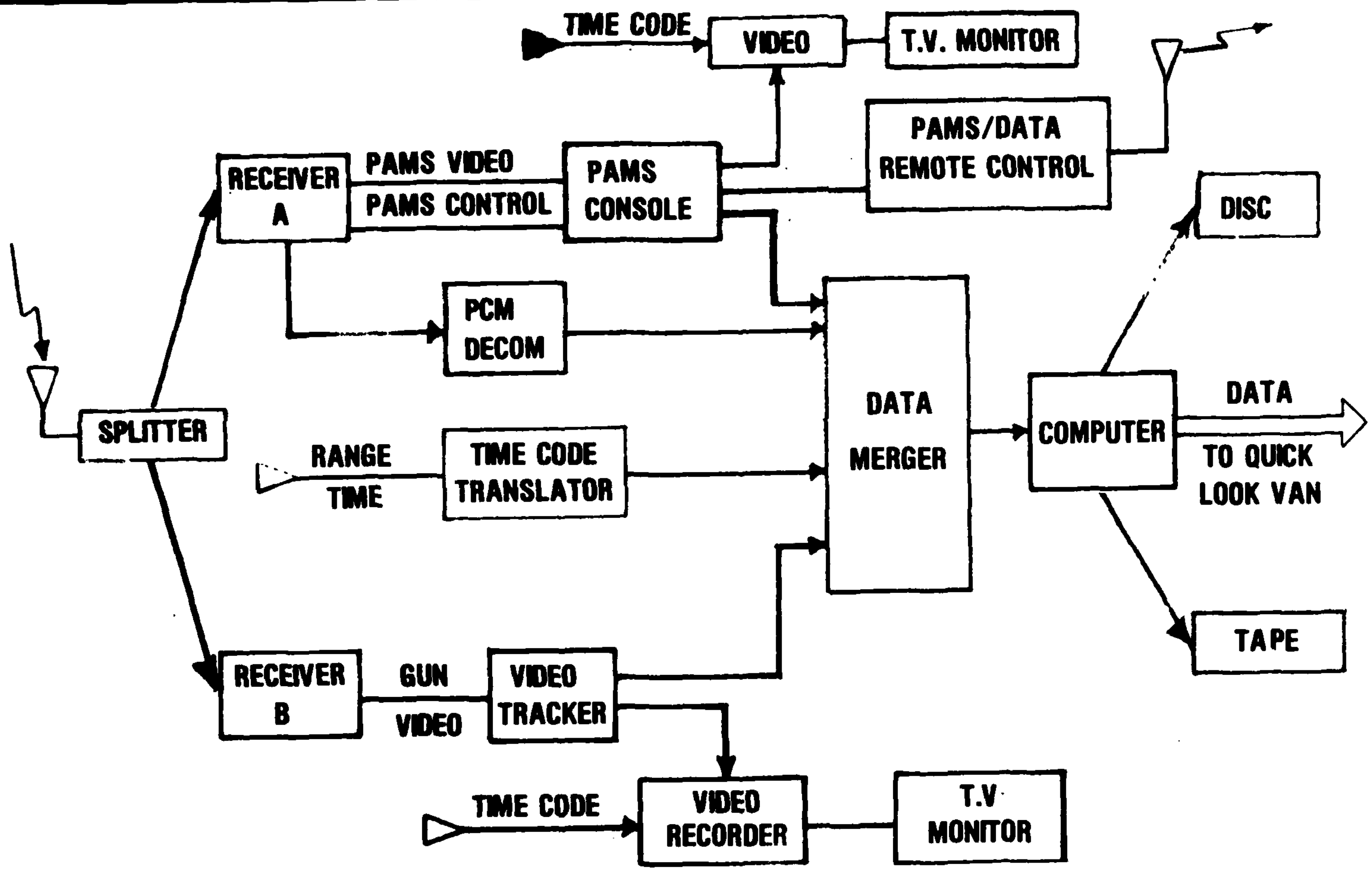


Figure 3-27. Block diagram of telemetry test site terminal for DIVADS check test.

3.3 (Cont'd)

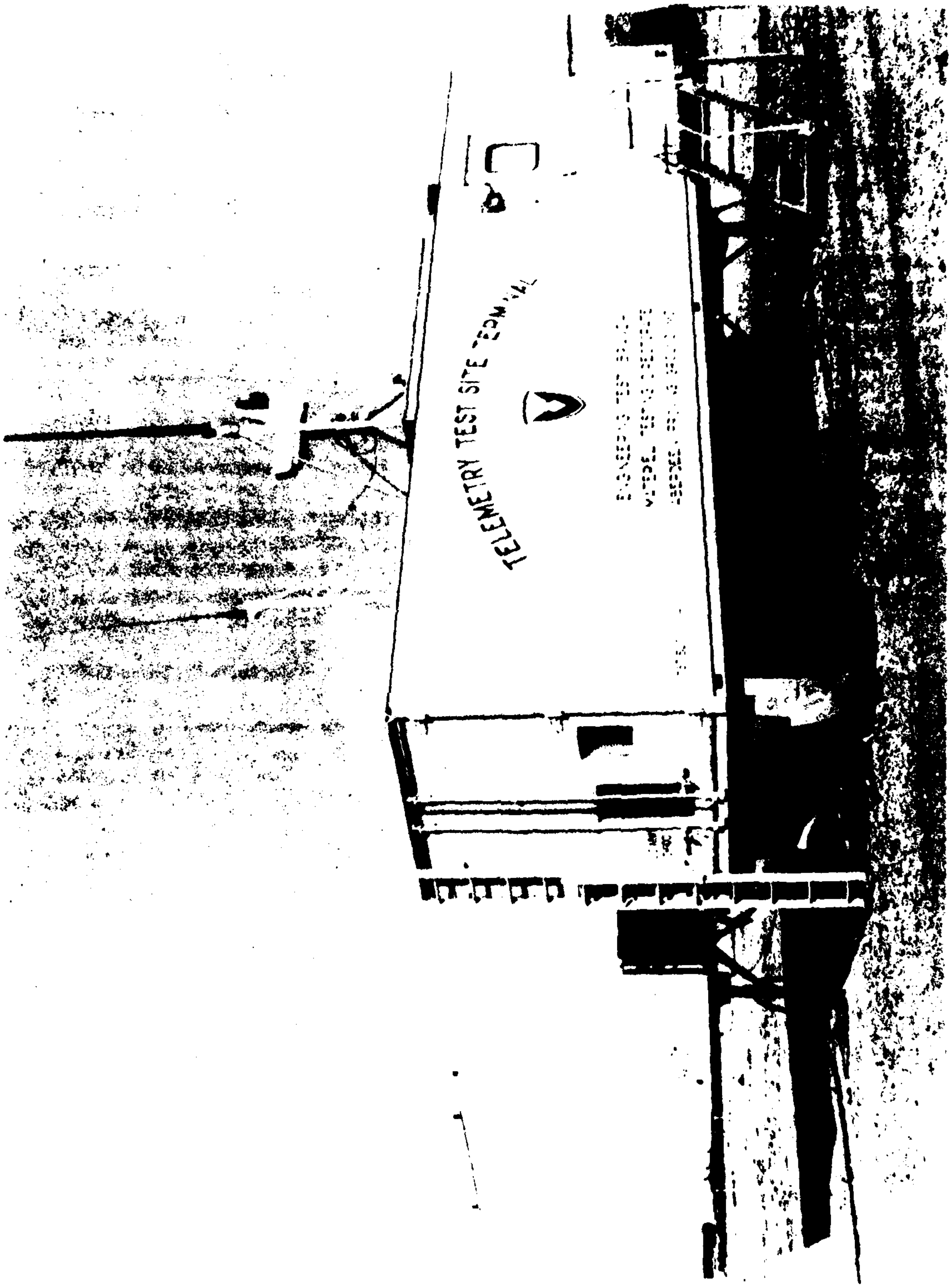


Figure 2-28. Telemetry test site terminal external view.

3.3 (Cont'd)

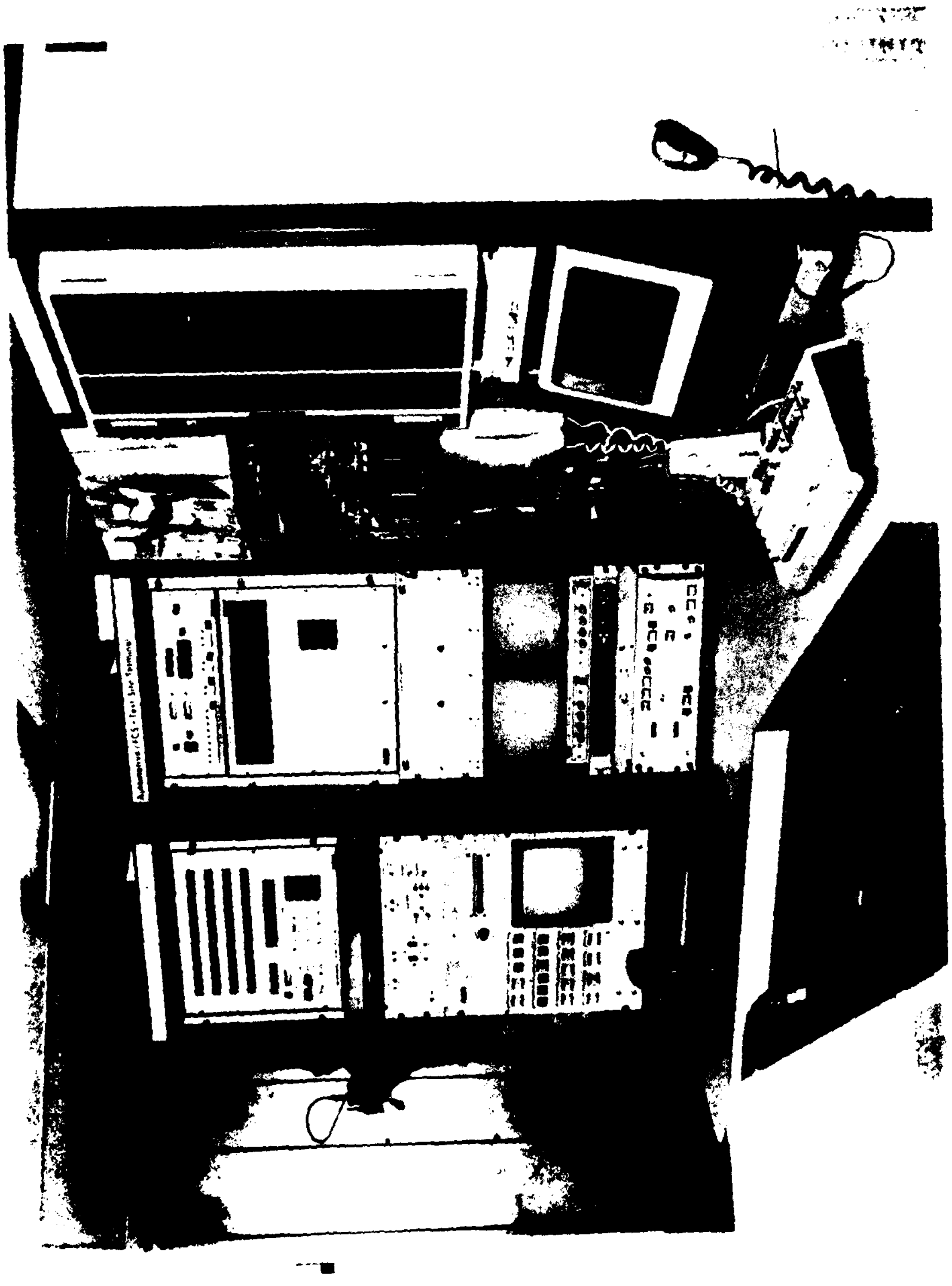


Figure 3-29. Telemetry test site terminal interior, operations console.

3.3 (Cont'd)

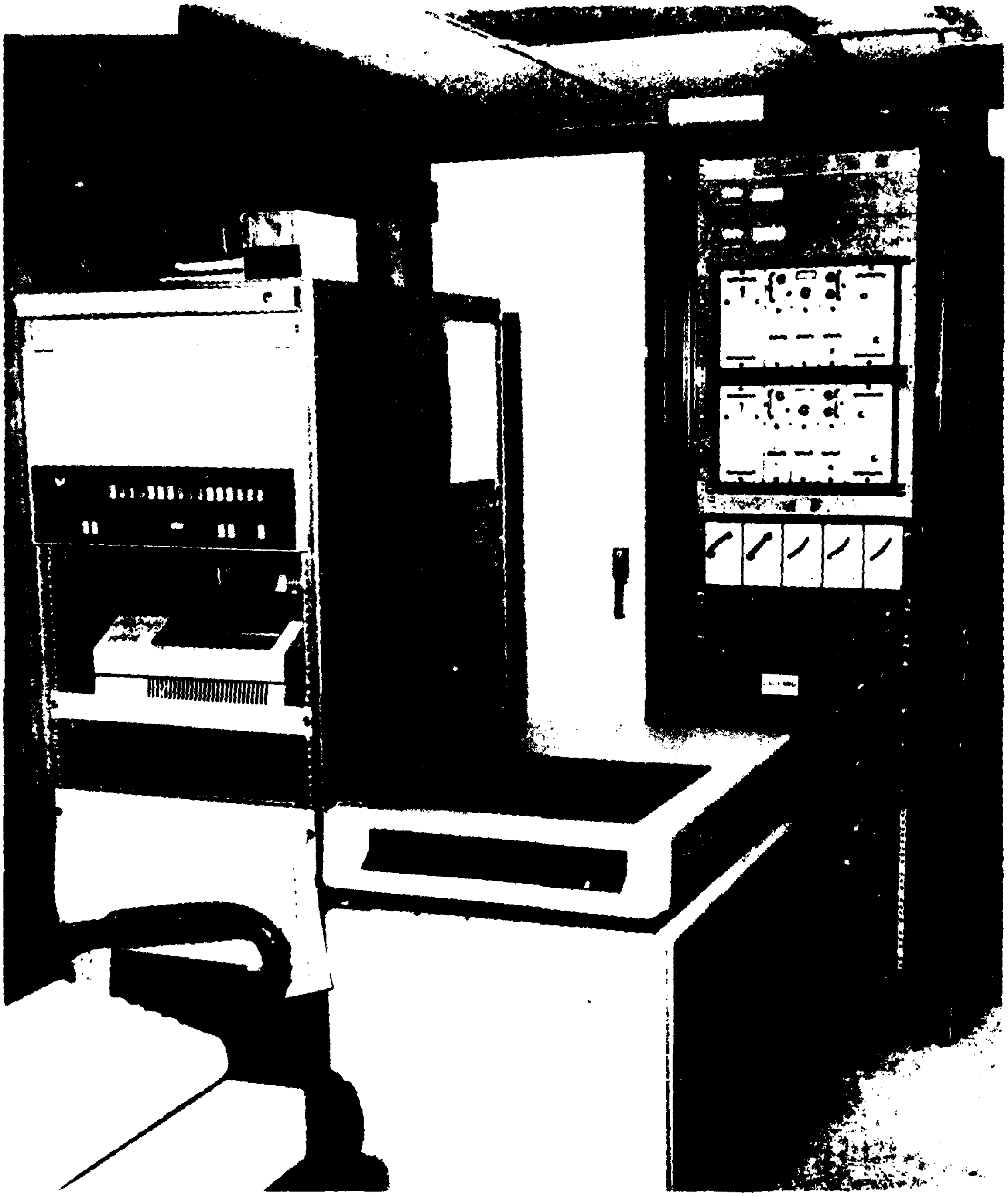


Figure 3-30. Telemetry test site terminal interior minicomputer and telemetry instrumentation.

The data acquisition system was enhanced to accommodate air defense systems testing and to take advantage of the real time tracking data from PAMS. These enhancements consist of:

a. Addition of PAMS control console.

b. Addition of the remote control for the instrumentation interface.

c. Addition of an RF control link to tramsmit control signals to the on-board package.

d. Implementation of a high speed parallel data link to allow rapid transfer of data from the data acquisition system to data analysis test site terminal.

e. Modification of the PCM system to expand the PCM data word size from 15 to 16 bits.

f. Addition of an RF control link to transmit control signals to the calibration targets used for initial alinement check and daily alinement check.

The instrumentation interface remote control allows the selection of PAMS acquisition reference (DIVADS radar, sight, gun, or none), controls the power to the vertical gyro system (VGS), allows the VGS erection mechanism to be disabled, remotely resets the instrumentation interface microcomputer, and resets the MVR processor. This unit is based on serial-digital data transmission and uses MIL-STD-1553 encoder/decoders although it does not conform to the MIL-STD-1553 protocol.

The interface remote control signal is time division multiplexed with the PAMS control signal (also a serial-digital transmission) onto a single radio frequency (RF) control link.

The high speed parallel data link allows data to be transferred at rates in excess of 100,000 words/sec between the disks of two computers. The link hardware consists of an interface card in each computer, a line driver circuit in the data acquisition source computer, a line receiver circuit in the data analysis computer, and interconnecting cables. The link software consists of network routines to set up the transfer, and self-contained direct memory access (DMA) machine control routines to perform the actual data transfer.

3.4 DIVADS CHECK TEST REVIEW

PAMS was very successful in its application to the DIVADS check test. Some areas where shortcomings appeared are covered in the following paragraphs.

3.4.1 Tracking Rates

In an effort to deduce the tracking rates at which PAMS maintains track, PAMS and MIDI data from the DIVADS check test were examined. This data revealed that PAMS tracked targets reliably at rates on the order of 54°/sec, and that PAMS tracked targets with mixed success to rates on the order of 72°/sec.

This examination, in addition, indicated that targets rates in excess of 140°/sec were encountered during the DIVADS check test.

A re-evaluation of PAMS tracking algorithms reveals that a rate-aided algorithm would allow higher speed tracking. To implement rate-aided tracking, however, requires that range information be included. A laser range measuring device could be added to PAMS to allow this mode of tracking. In addition, a segmented detector could be used to implement a primitive laser track mode.

3.4.2 Smoke

Dependent upon the angle of fire and the meteorological conditions, smoke from the firing weapons could obscure the target from PAMS, and in the case of high azimuth rate targets could cause the loss of the target.

PAMS is a daytime video system, and as such, must have a visible target to track. Since infrared attenuation by smoke is less than visible attenuation, the possibility of using a forward looking infrared (FLIR) sensor has been considered.

3.4.3 Nighttime Use

PAMS can be useful in a nighttime scenario only with an enhanced target. The testing community is not receptive to the thought of enhancing targets. The use of a FLIR sensor has been considered, and would function for nighttime tracking.

4. CONCLUSIONS

a. The tracking accuracy of PAMS, within the constraints of track point definition, is within the ±1 mrad specification.

b. PAMS does not reliably track targets at the limits of the specified rates.

c. PAMS can be successfully integrated into air defense systems testing, and has played a significant role in the design test/operations test (DT/OT) of DIVADS and the DIVADS check test.

5. RECOMMENDATIONS

a. PAMS be used on all tracking tests of gun air defense weapon systems.

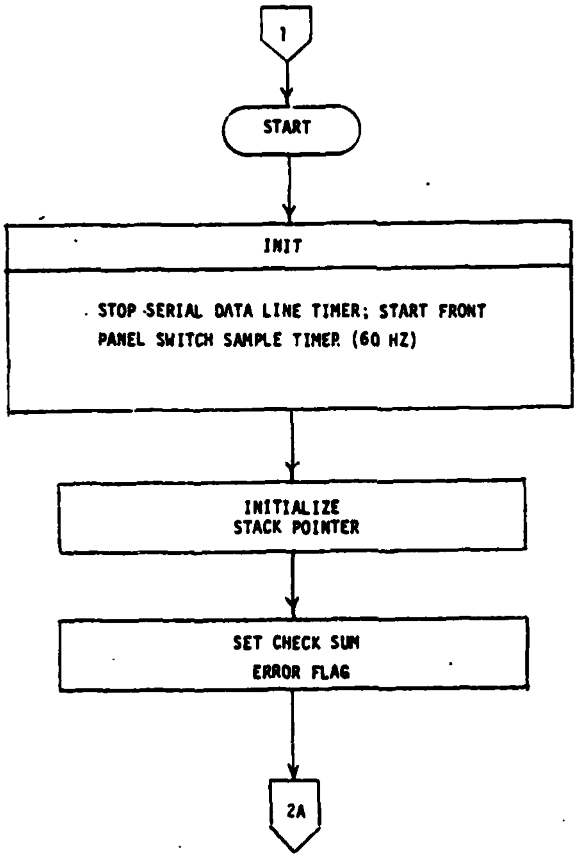
b. A laser range measuring capability be added to PAMS so as to allow rate-aided tracking and primitive laser tracking, and hence increase the upper limit on tracking rates.

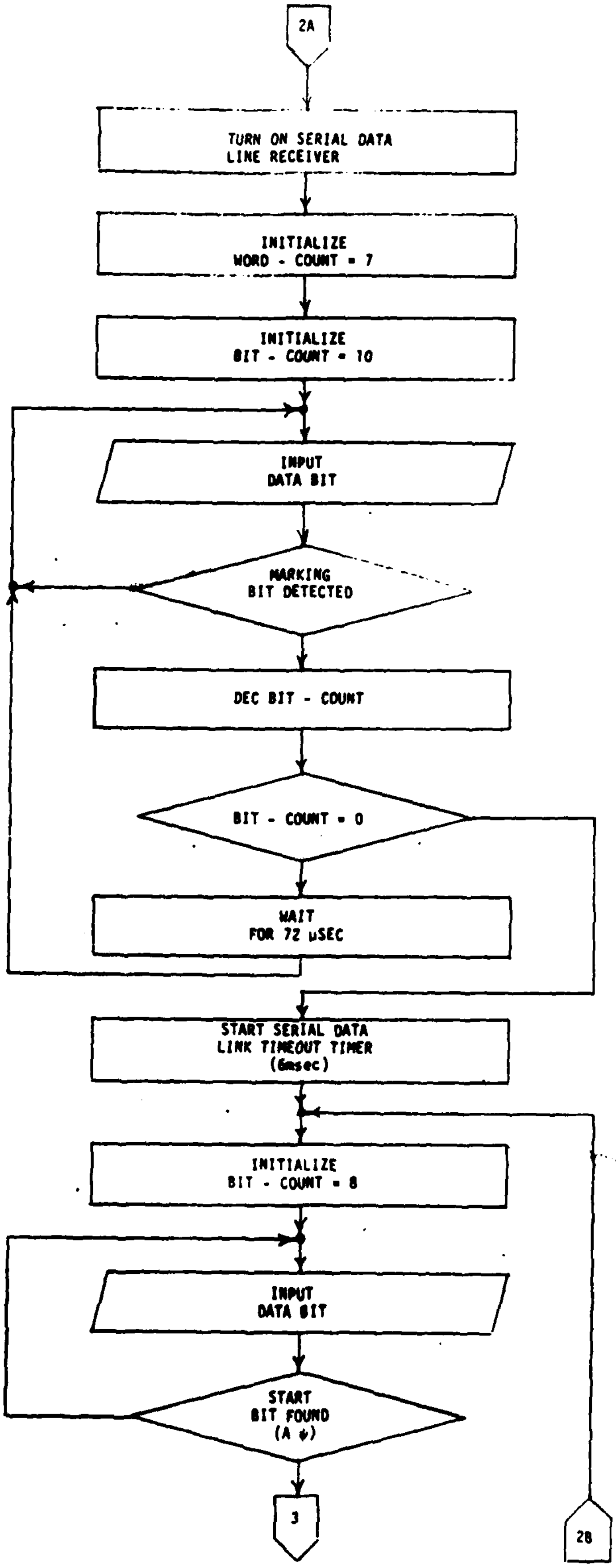
c. A PAMS with a FLIR sensor be developed to enhance performance under smoke conditions and to allow effective nighttime use.

d. Further accuracy tests be performed.

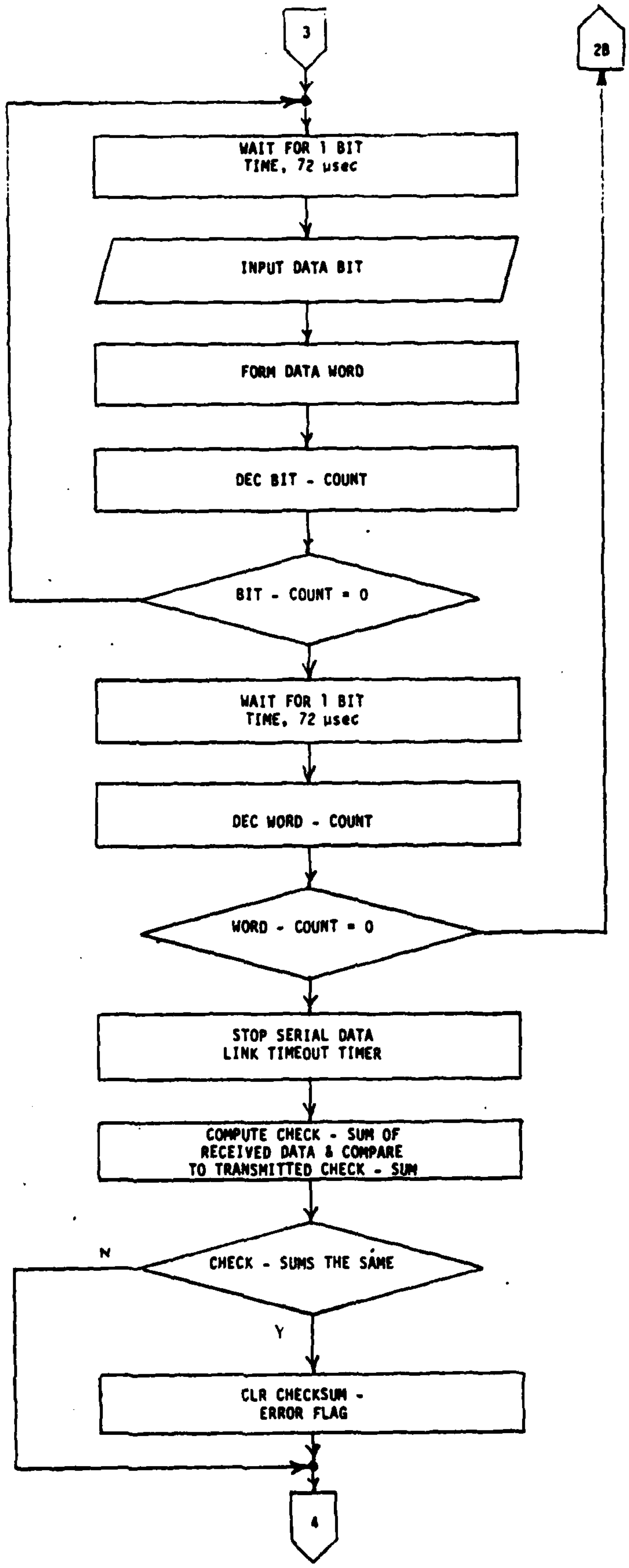
SECTION 2. APPENDICES

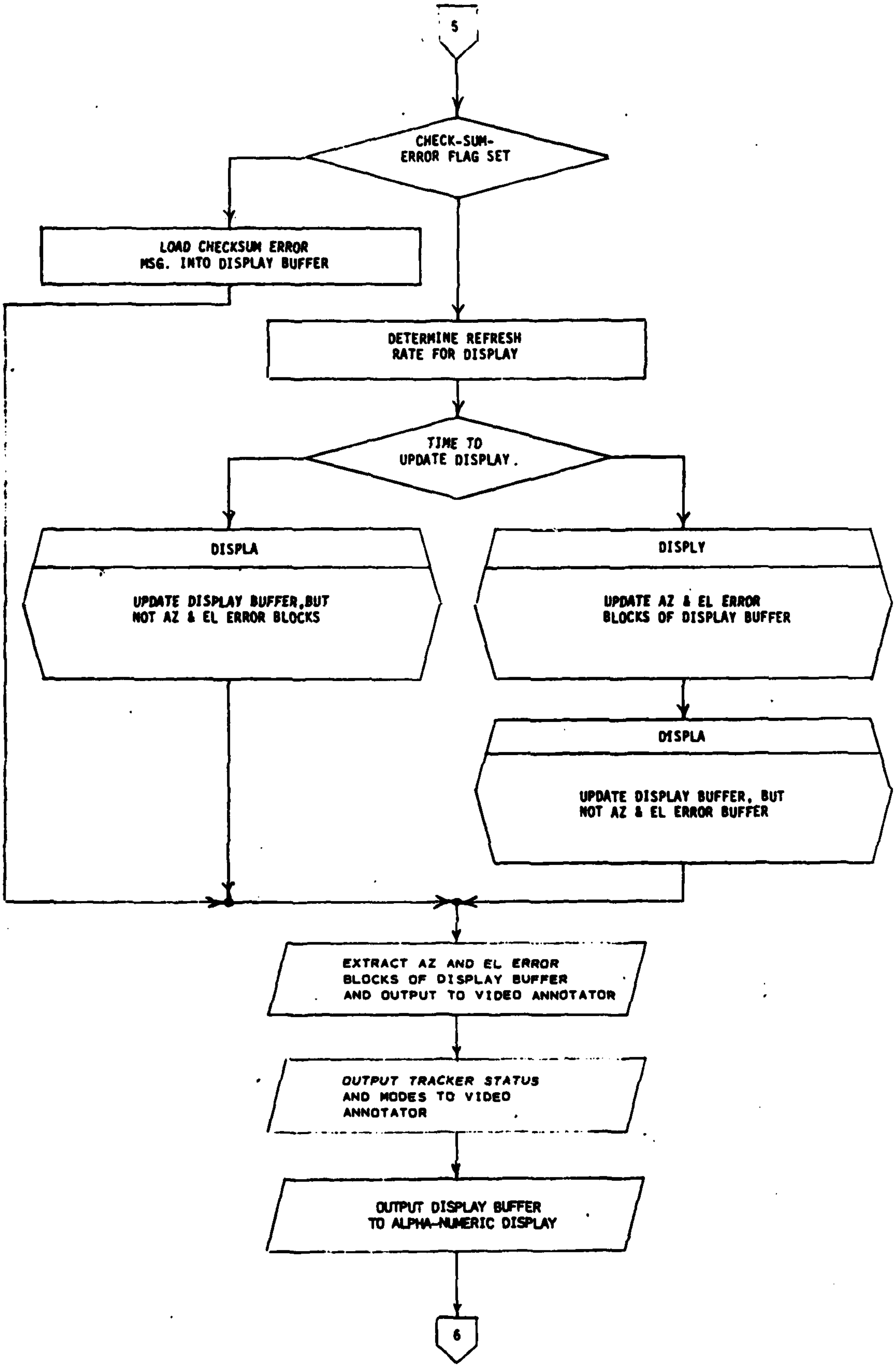
APPENDIX A - CONTROL STATION SOFTWARE DIAGRAMS

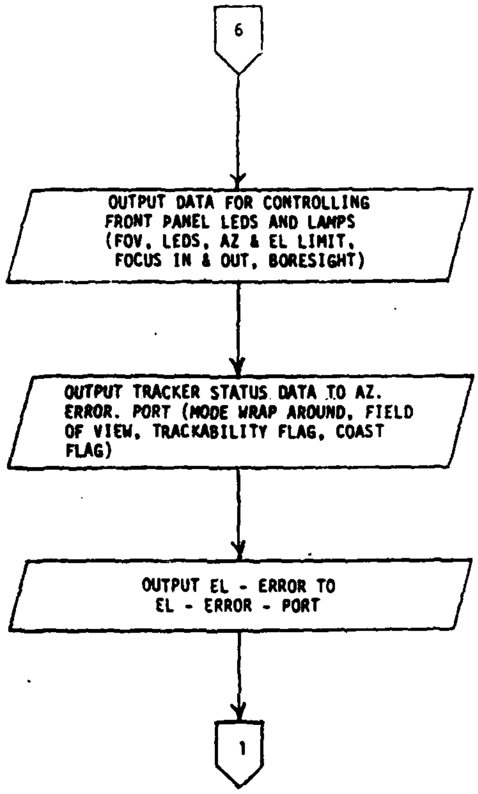


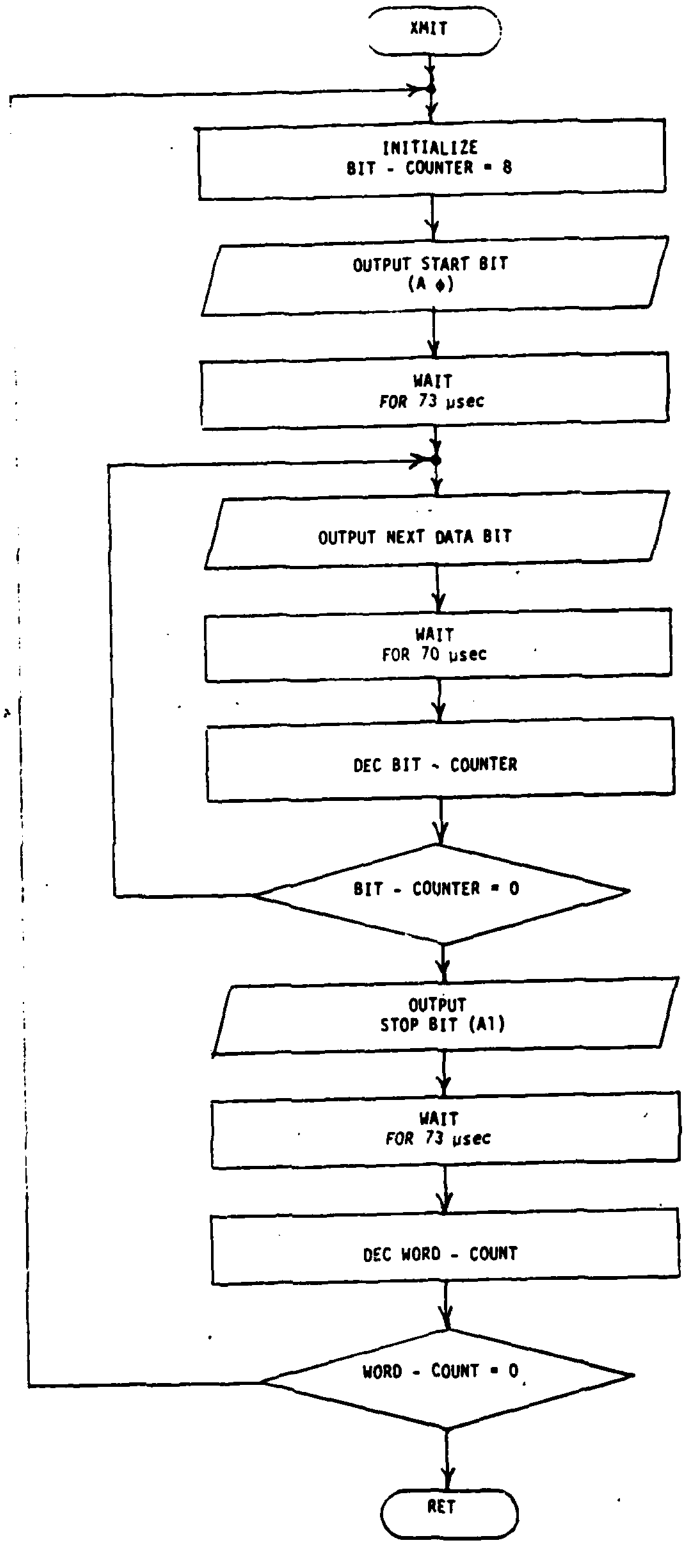


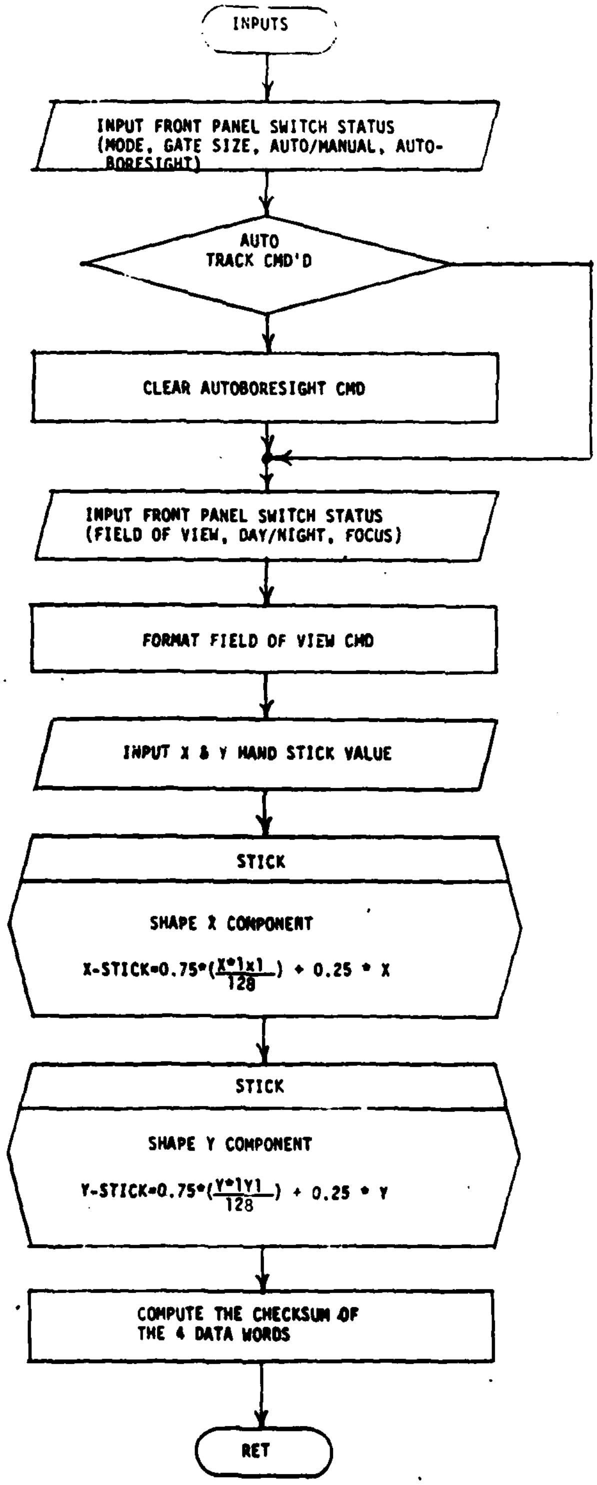
2A
TURN ON SERIAL DATA LINE RECEIVER
INITIALIZE WORD - COUNT = 7
INITIALIZE BIT - COUNT = 10
INPUT DATA BIT
MARKING BIT DETECTED
DEC BIT - COUNT
BIT - COUNT = 0
WAIT FOR 72 μSEC
START SERIAL DATA LINK TIMEOUT TIMER (6msec)
INITIALIZE BIT - COUNT = 8
INPUT DATA BIT
START BIT FOUND (A ↓)
3
2B

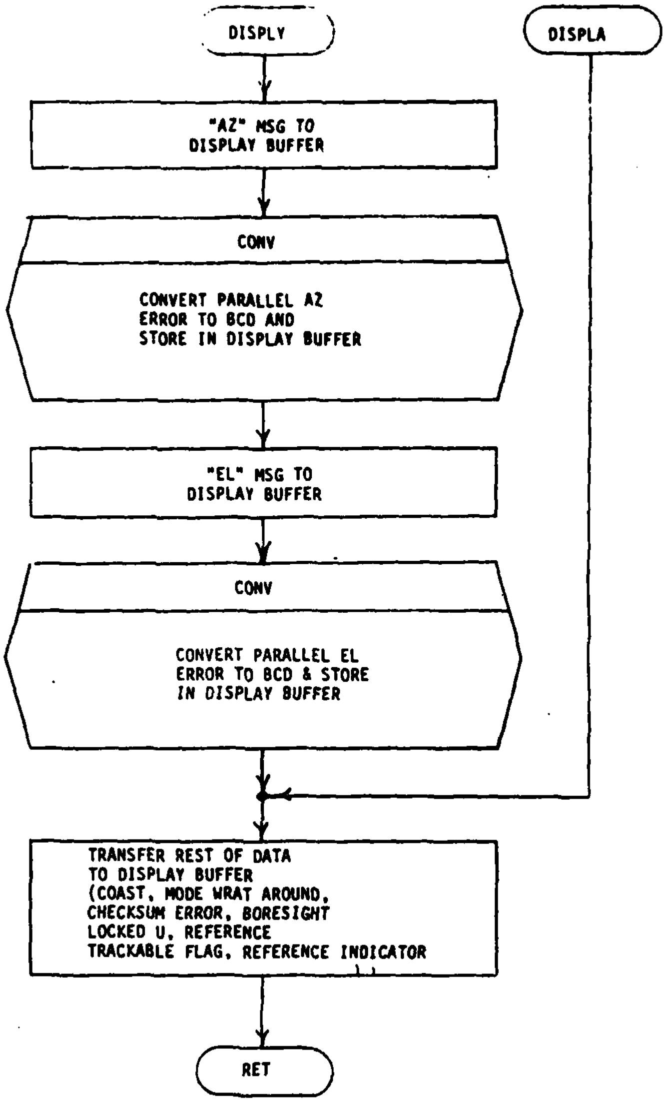

3
2B
WAIT FOR 1 BIT
TIME, 72 μsec
INPUT DATA BIT
FORM DATA WORD
DEC BIT - COUNT
BIT - COUNT = 0
WAIT FOR 1 BIT
TIME, 72 μsec
DEC WORD - COUNT
WORD - COUNT = 0
STOP SERIAL DATA
LINK TIMEOUT TIMER
COMPUTE CHECK - SUM OF
RECEIVED DATA & COMPARE
TO TRANSMITTED CHECK - SUM
CHECK - SUMS THE SAME
N
Y
CLR CHECKSUM -
ERROR FLAG
4


5
CHECK-SUM-
ERROR FLAG SET
LOAD CHECKSUM ERROR
MSG. INTO DISPLAY BUFFER
DETERMINE REFRESH
RATE FOR DISPLAY
TIME TO
UPDATE DISPLAY.
DISPLA
UPDATE DISPLAY BUFFER,BUT
NOT AZ & EL ERROR BLOCKS
DISPLY
UPDATE AZ & EL ERROR
BLOCKS OF DISPLAY BUFFER
DISPLA
UPDATE DISPLAY BUFFER, BUT
NOT AZ & EL ERROR BUFFER
EXTRACT AZ AND EL ERROR
BLOCKS OF DISPLAY BUFFER
AND OUTPUT TO VIDEO ANNOTATOR
OUTPUT TRACKER STATUS
AND MODES TO VIDEO
ANNOTATOR
OUTPUT DISPLAY BUFFER
TO ALPHA-NUMERIC DISPLAY
6


6
OUTPUT DATA FOR CONTROLLING FRONT PANEL LEDS AND LAMPS (FOV, LEDS, AZ & EL LIMIT, FOCUS IN & OUT, BORESIGHT)
OUTPUT TRACKER STATUS DATA TO AZ. ERROR. PORT (MODE WRAP AROUND, FIELD OF VIEW, TRACKABILITY FLAG, COAST FLAG)
OUTPUT EL - ERROR TO EL - ERROR - PORT
1

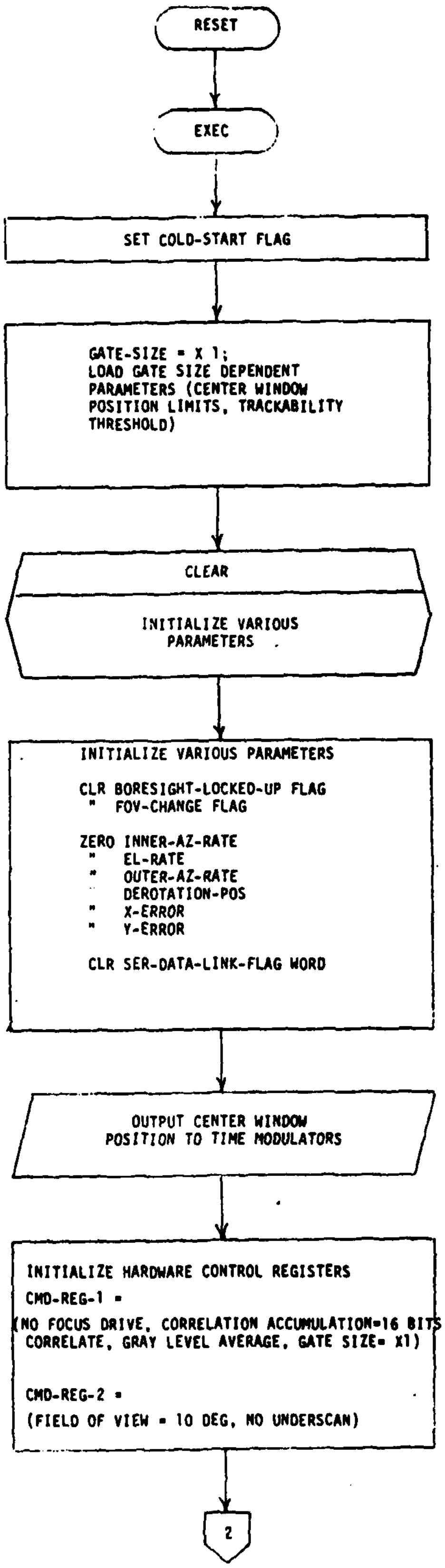

XMIT
INITIALIZE
BIT - COUNTER = 8
OUTPUT START BIT
(A ϕ)
WAIT
FOR 73 μsec
OUTPUT NEXT DATA BIT
WAIT
FOR 70 μsec
DEC BIT - COUNTER
BIT - COUNTER = 0
OUTPUT
STOP BIT (A1)
WAIT
FOR 73 μsec
DEC WORD - COUNT
WORD - COUNT = 0
RET

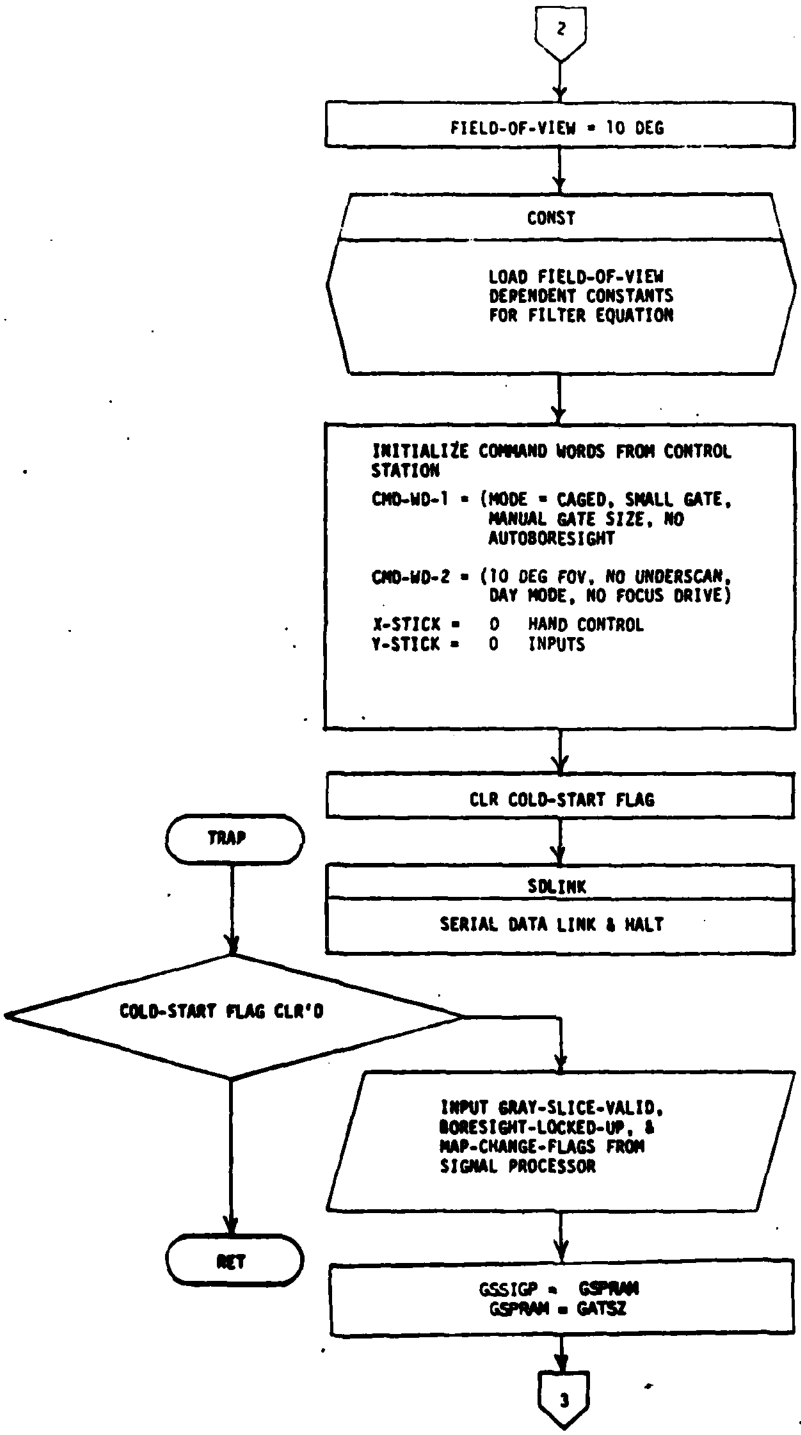

INPUTS
INPUT FRONT PANEL SWITCH STATUS (MODE, GATE SIZE, AUTO/MANUAL, AUTO-BORESIGHT)
AUTO TRACK CMD'D
CLEAR AUTOBORESIGHT CMD
INPUT FRONT PANEL SWITCH STATUS (FIELD OF VIEW, DAY/NIGHT, FOCUS)
FORMAT FIELD OF VIEW CMD
INPUT X & Y HAND STICK VALUE
STICK
SHAPE X COMPONENT
X-STICK=0.75*(X*|X|/128) + 0.25 * X
STICK
SHAPE Y COMPONENT
Y-STICK=0.75*(Y*|Y|/128) + 0.25 * Y
COMPUTE THE CHECKSUM OF THE 4 DATA WORDS
RET

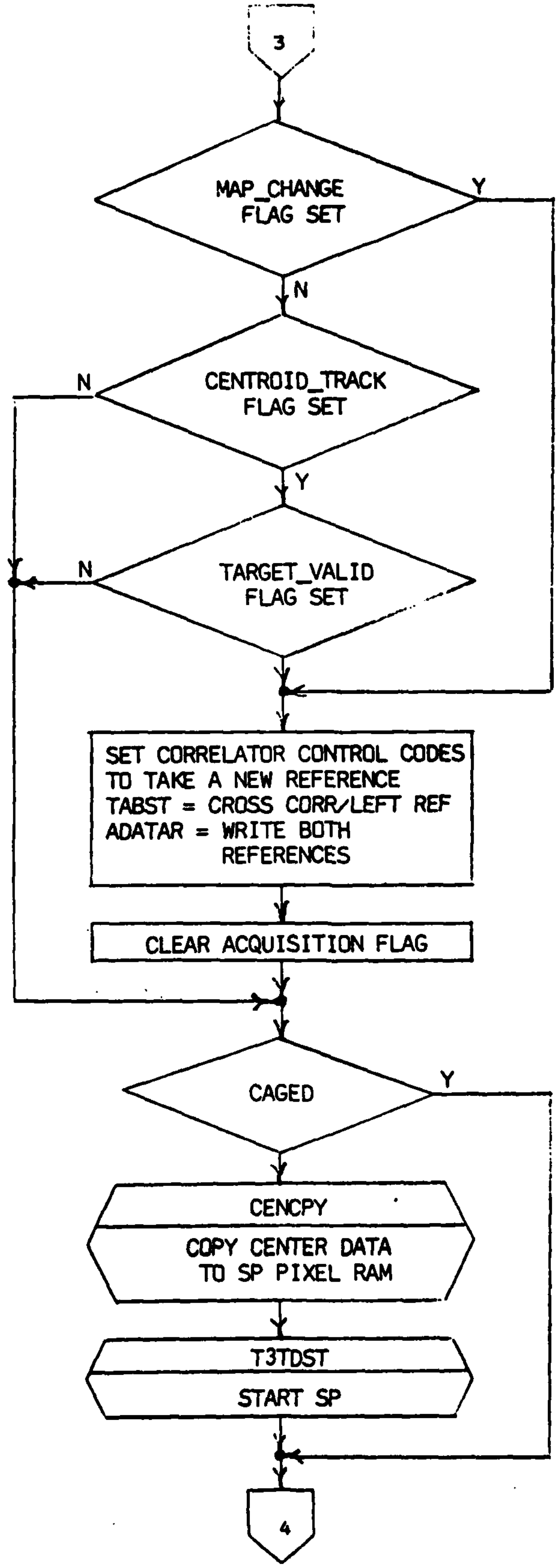

DISPLY
DISPLA
"AZ" MSG TO DISPLAY BUFFER
CONV
CONVERT PARALLEL AZ ERROR TO BCD AND STORE IN DISPLAY BUFFER
"EL" MSG TO DISPLAY BUFFER
CONV
CONVERT PARALLEL EL ERROR TO BCD & STORE IN DISPLAY BUFFER
TRANSFER REST OF DATA TO DISPLAY BUFFER (COAST, MODE WRAT AROUND, CHECKSUM ERROR, BORESIGHT LOCKED U, REFERENCE TRACKABLE FLAG, REFERENCE INDICATOR
RET

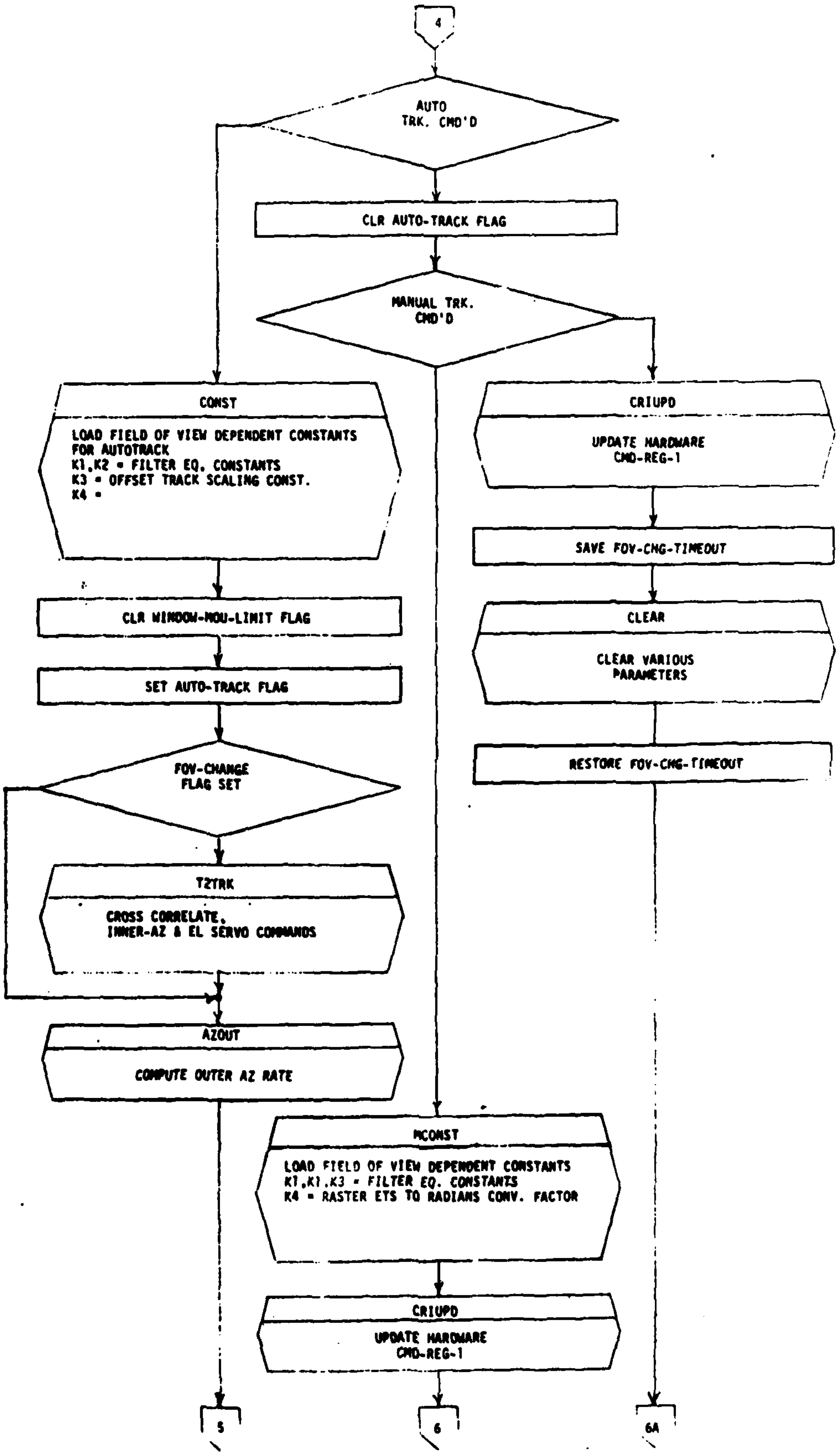
CHECKSUM ERROR FLAG	EFLAG	SET IF A CHECKSUM ERROR HAS BEEN DETECTED	
BIT-COUNT	-	SERIAL DATA LINK BIT UNITS	
WORD-COUNT	-	SERIAL DATA LINK WORD COUNTER	
AZ-ERROR	DSTACK+16	PARALLEL AZIMUTH GUN POINTING ANGLE	FROM ELECTRONICS BOX
EL-ERROR	DSTACK+18	PARALLEL ELEVATION GUN POINTING ANGLE	
X-STICK	DSTACK+2	SHAPED X COMPONENT OF HAND CONTROL	
Y-STICK	DSTACK+3	SHAPED Y COMPONENT OF HAND CONTROL	
X	DACQX	UNMODIFIED X INPUT FROM HAND CONTROL	
Y	DACQY	UNMODIFIED Y INPUT FORM HAND CONTROL	

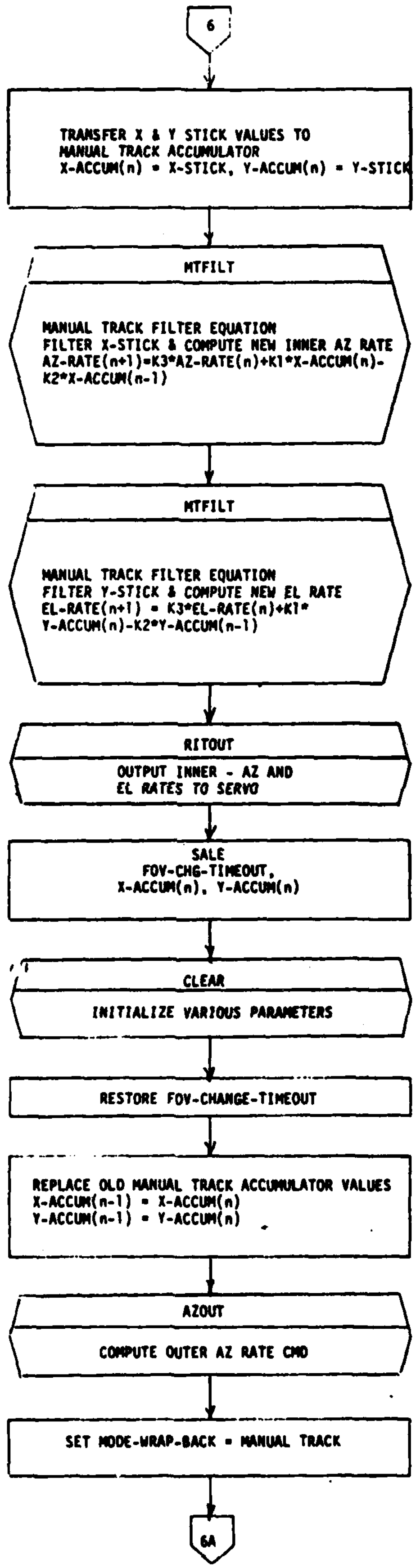
APPENDIX B - TRACK PROCESSOR SOFTWARE DIAGRAMS

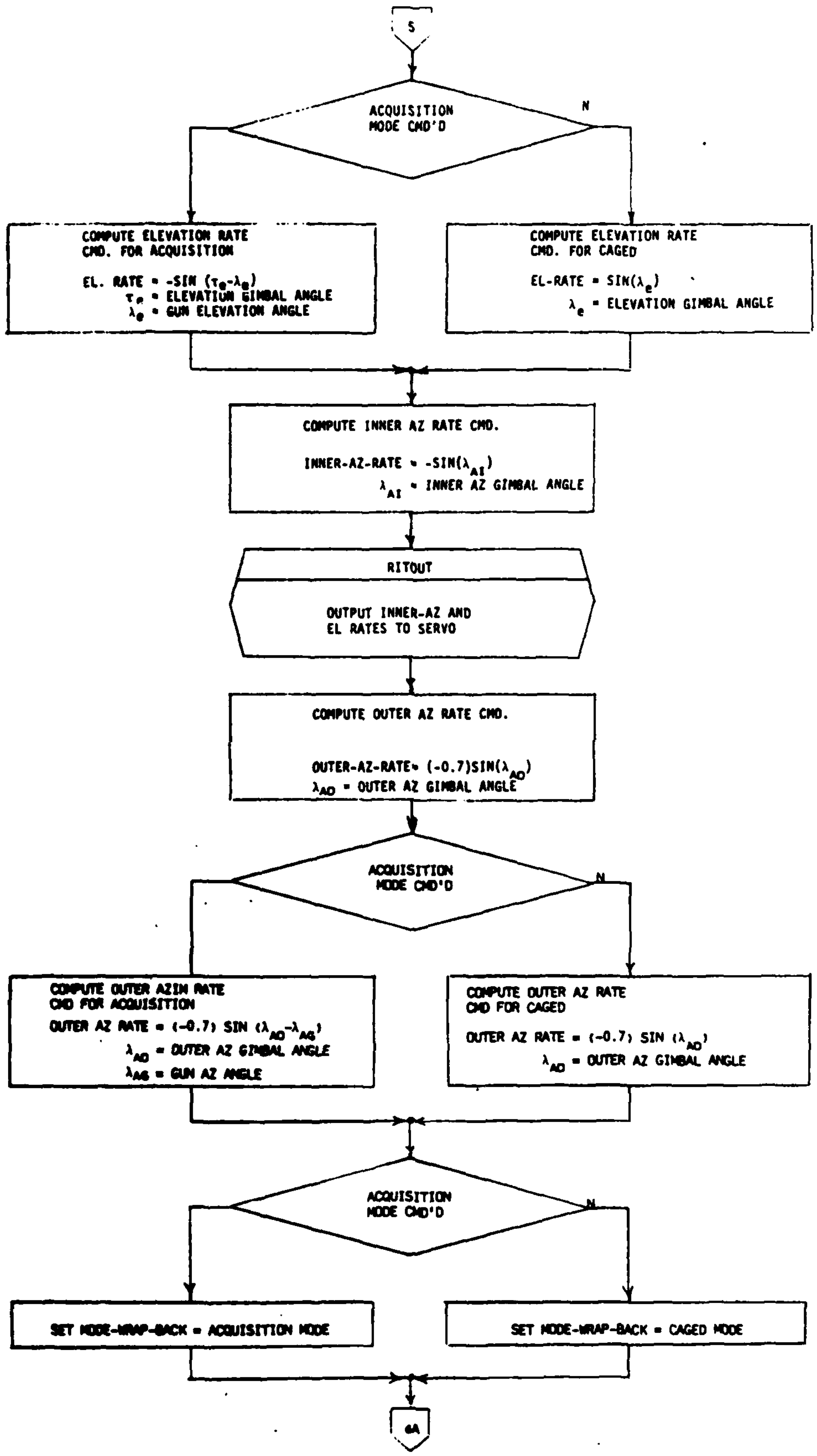


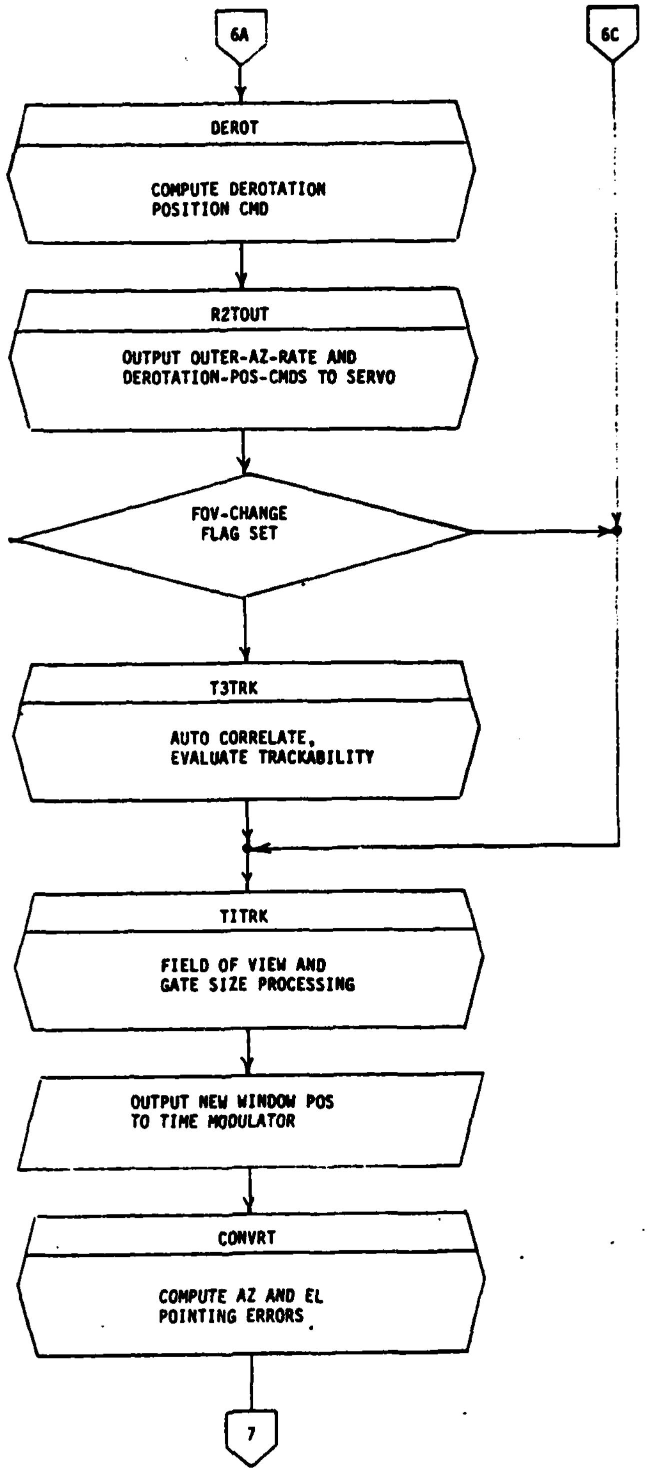

2
FIELD-OF-VIEW = 10 DEG
CONST
LOAD FIELD-OF-VIEW DEPENDENT CONSTANTS FOR FILTER EQUATION
INITIALIZE COMMAND WORDS FROM CONTROL STATION
CMD-WD-1 = (MODE = CAGED, SMALL GATE, MANUAL GATE SIZE, NO AUTOBORESIGHT
CMD-WD-2 = (10 DEG FOV, NO UNDERSCAN, DAY MODE, NO FOCUS DRIVE)
X-STICK = 0 HAND CONTROL
Y-STICK = 0 INPUTS
CLR COLD-START FLAG
TRAP
SDLINK
SERIAL DATA LINK & HALT
COLD-START FLAG CLR'D
INPUT GRAY-SLICE-VALID, BORESIGHT-LOCKED-UP, & MAP-CHANGE-FLAGS FROM SIGNAL PROCESSOR
RET
GSSIGP = GSPRAM
GSPRAM = GATSZ
3

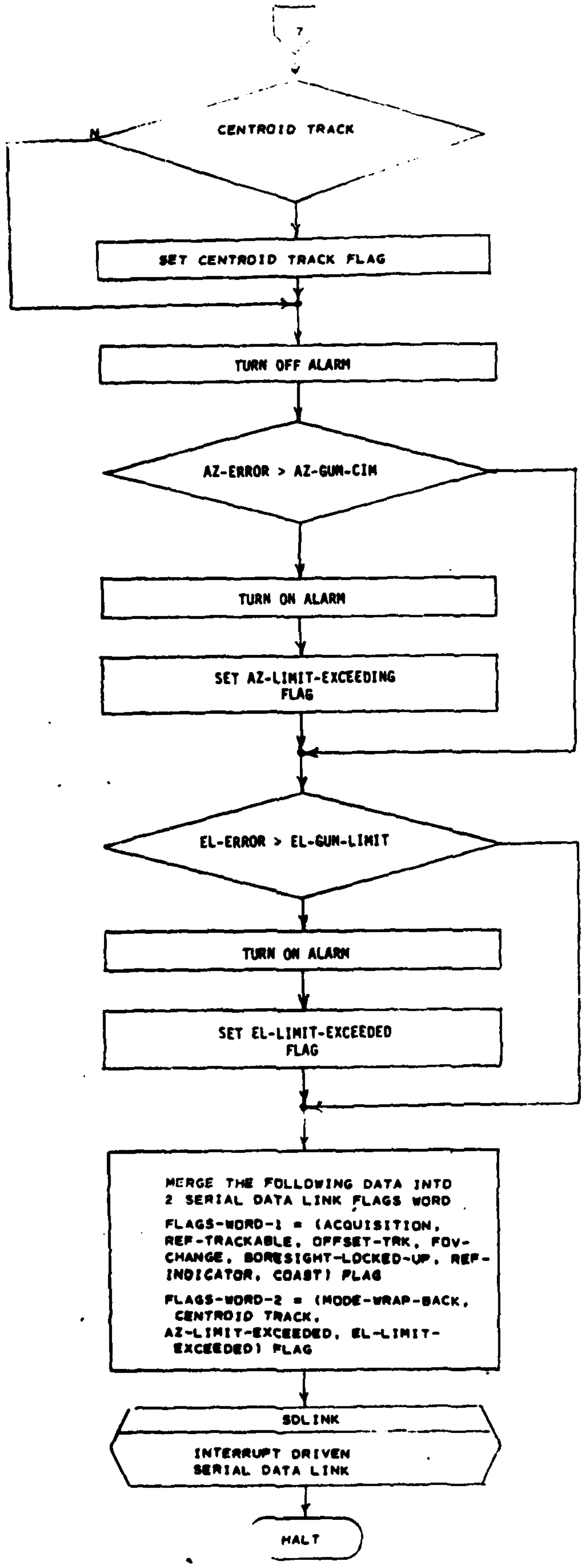

3
MAP_CHANGE FLAG SET
Y
N
CENTROID_TRACK FLAG SET
N
Y
TARGET_VALID FLAG SET
N
SET CORRELATOR CONTROL CODES TO TAKE A NEW REFERENCE
TABST = CROSS CORR/LEFT REF
ADATAR = WRITE BOTH REFERENCES
CLEAR ACQUISITION FLAG
CAGED
Y
CENCPY
COPY CENTER DATA TO SP PIXEL RAM
T3TDST
START SP
4

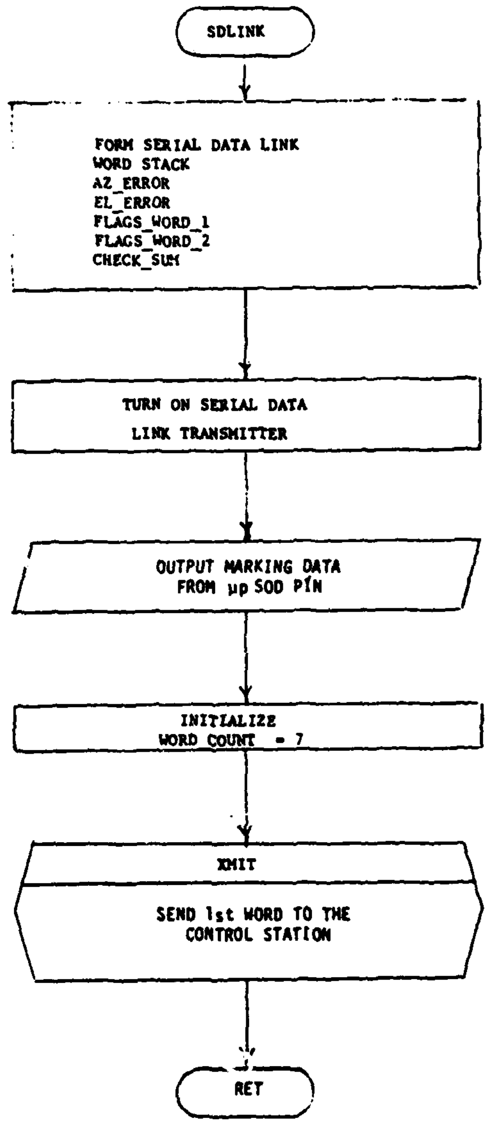

4
AUTO TRK. CMD'D
CLR AUTO-TRACK FLAG
MANUAL TRK. CMD'D
CONST
LOAD FIELD OF VIEW DEPENDENT CONSTANTS FOR AUTOTRACK
K1,K2 = FILTER EQ. CONSTANTS
K3 = OFFSET TRACK SCALING CONST.
K4 =
CRIUPD
UPDATE HARDWARE CMD-REG-1
SAVE FOV-CHG-TIMEOUT
CLR WINDOW-MOU-LIMIT FLAG
CLEAR
CLEAR VARIOUS PARAMETERS
SET AUTO-TRACK FLAG
RESTORE FOV-CHG-TIMEOUT
FOV-CHANGE FLAG SET
T2TRK
CROSS CORRELATE, INNER-AZ & EL SERVO COMMANDS
AZOUT
COMPUTE OUTER AZ RATE
MCONST
LOAD FIELD OF VIEW DEPENDENT CONSTANTS
K1,K1,K3 = FILTER EQ. CONSTANTS
K4 = RASTER ETS TO RADIANS CONV. FACTOR
CRIUPD
UPDATE HARDWARE CMD-REG-1
5
6
6A

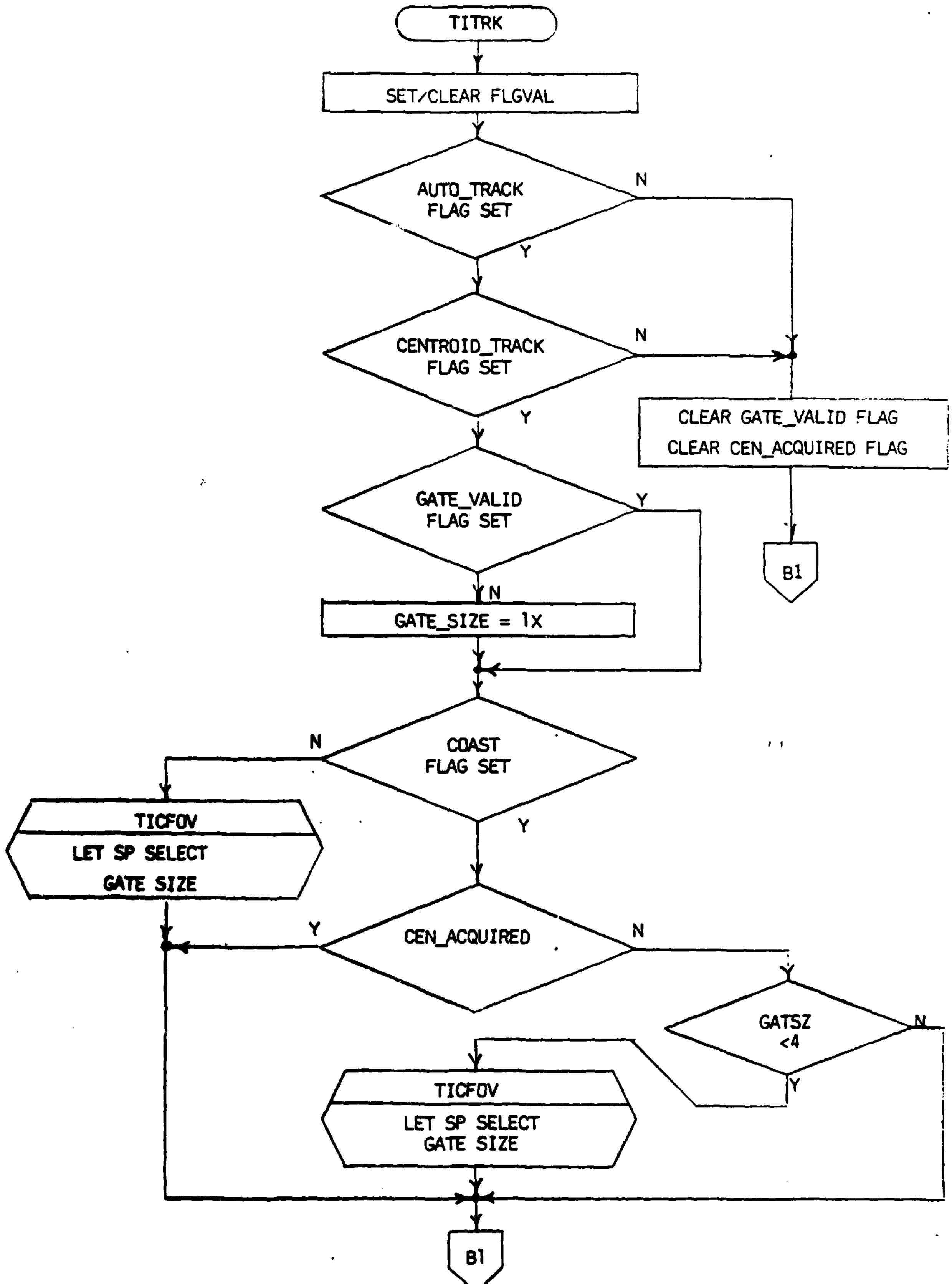

6
TRANSFER X & Y STICK VALUES TO
MANUAL TRACK ACCUMULATOR
X-ACCUM(n) = X-STICK, Y-ACCUM(n) = Y-STICK
MTFILT
MANUAL TRACK FILTER EQUATION
FILTER X-STICK & COMPUTE NEW INNER AZ RATE
AZ-RATE(n+1)=K3*AZ-RATE(n)+K1*X-ACCUM(n)-
K2*X-ACCUM(n-1)
MTFILT
MANUAL TRACK FILTER EQUATION
FILTER Y-STICK & COMPUTE NEW EL RATE
EL-RATE(n+1) = K3*EL-RATE(n)+K1*
Y-ACCUM(n)-K2*Y-ACCUM(n-1)
RITOUT
OUTPUT INNER - AZ AND
EL RATES TO SERVO
SALE
FOV-CHG-TIMEOUT,
X-ACCUM(n), Y-ACCUM(n)
CLEAR
INITIALIZE VARIOUS PARAMETERS
RESTORE FOV-CHANGE-TIMEOUT
REPLACE OLD MANUAL TRACK ACCUMULATOR VALUES
X-ACCUM(n-1) = X-ACCUM(n)
Y-ACCUM(n-1) = Y-ACCUM(n)
AZOUT
COMPUTE OUTER AZ RATE CMD
SET MODE-WRAP-BACK = MANUAL TRACK
6A

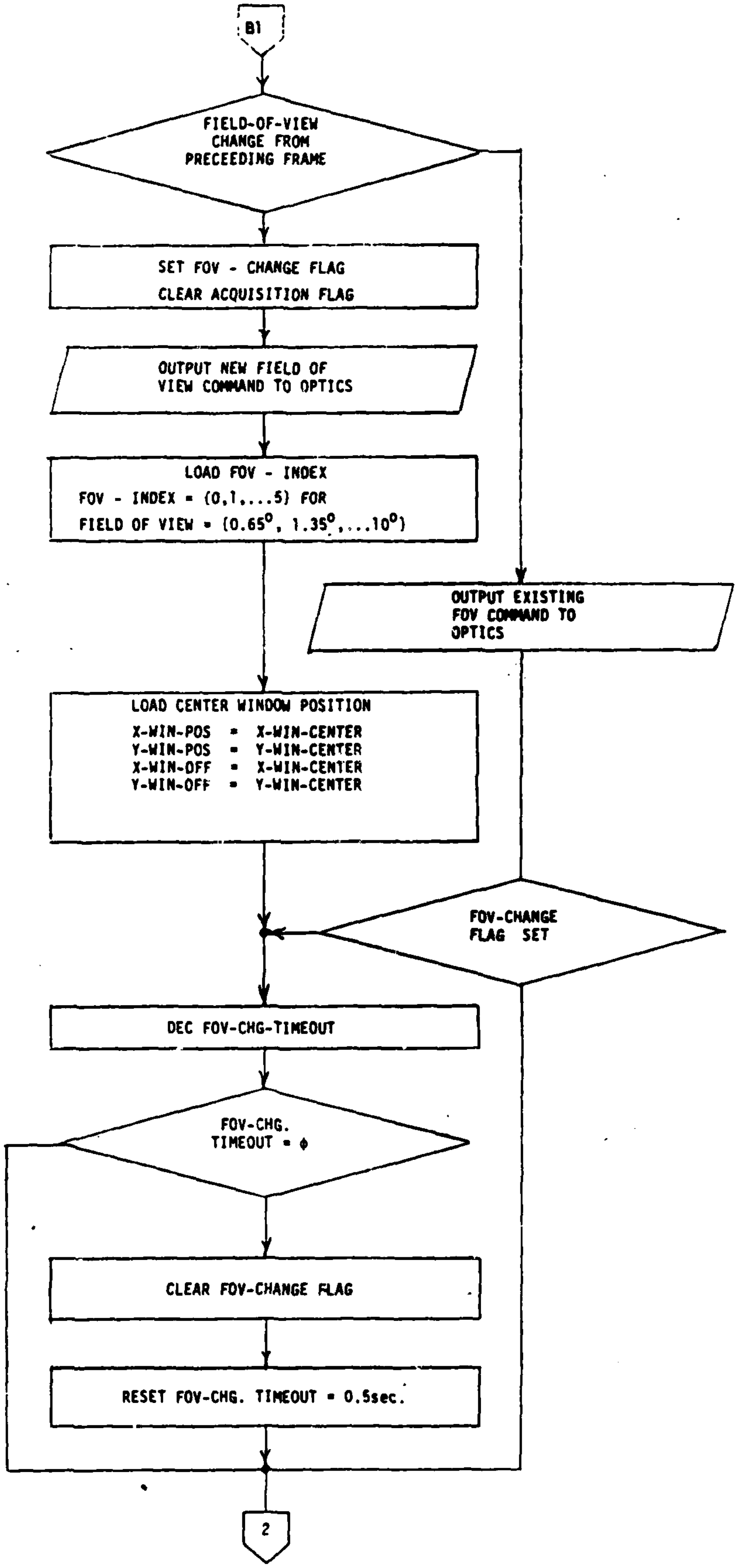

5
ACQUISITION MODE CMD'D
N
COMPUTE ELEVATION RATE CMD. FOR ACQUISITION
EL. RATE = -SIN (τ_e-λ_e)
τ_e = ELEVATION GIMBAL ANGLE
λ_e = GUN ELEVATION ANGLE
COMPUTE ELEVATION RATE CMD. FOR CAGED
EL-RATE = SIN(λ_e)
λ_e = ELEVATION GIMBAL ANGLE
COMPUTE INNER AZ RATE CMD.
INNER-AZ-RATE = -SIN(λ_{AI})
λ_{AI} = INNER AZ GIMBAL ANGLE
RITOUT
OUTPUT INNER-AZ AND EL RATES TO SERVO
COMPUTE OUTER AZ RATE CMD.
OUTER-AZ-RATE= (-0.7)SIN(λ_{AO})
λ_{AO} = OUTER AZ GIMBAL ANGLE
ACQUISITION MODE CMD'D
N
COMPUTE OUTER AZIM RATE CMD FOR ACQUISITION
OUTER AZ RATE = (-0.7) SIN (λ_{AO}-λ_{AG})
λ_{AO} = OUTER AZ GIMBAL ANGLE
λ_{AG} = GUN AZ ANGLE
COMPUTE OUTER AZ RATE CMD FOR CAGED
OUTER AZ RATE = (-0.7) SIN (λ_{AO})
λ_{AO} = OUTER AZ GIMBAL ANGLE
ACQUISITION MODE CMD'D
N
SET MODE-WRAP-BACK = ACQUISITION MODE
SET MODE-WRAP-BACK = CAGED MODE
6A

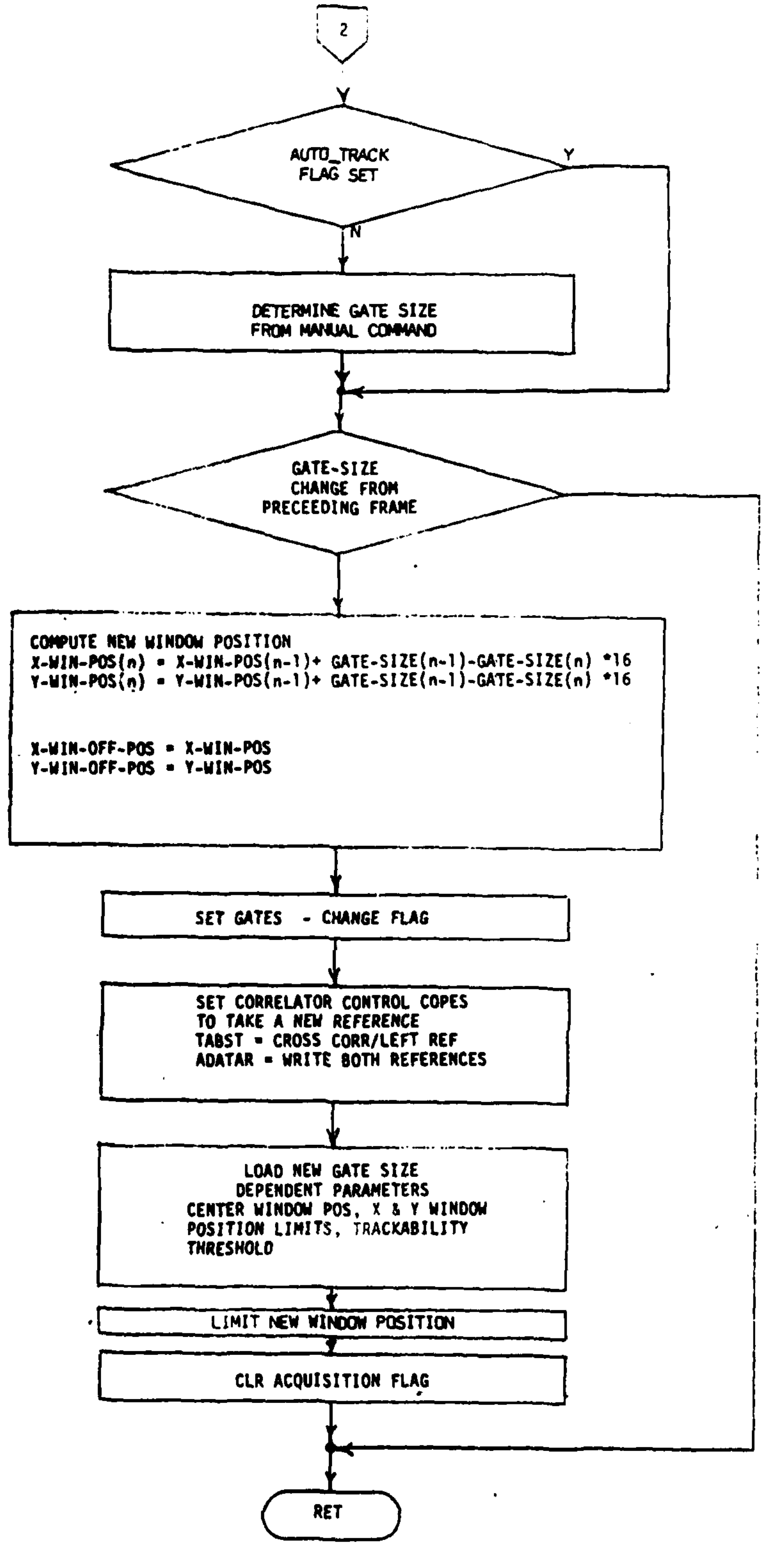

6A
6C
DEROT
COMPUTE DEROTATION
POSITION CMD
R2TOUT
OUTPUT OUTER-AZ-RATE AND
DEROTATION-POS-CMDS TO SERVO
FOV-CHANGE
FLAG SET
T3TRK
AUTO CORRELATE,
EVALUATE TRACKABILITY
T1TRK
FIELD OF VIEW AND
GATE SIZE PROCESSING
OUTPUT NEW WINDOW POS
TO TIME MODULATOR
CONVRT
COMPUTE AZ AND EL
POINTING ERRORS
7

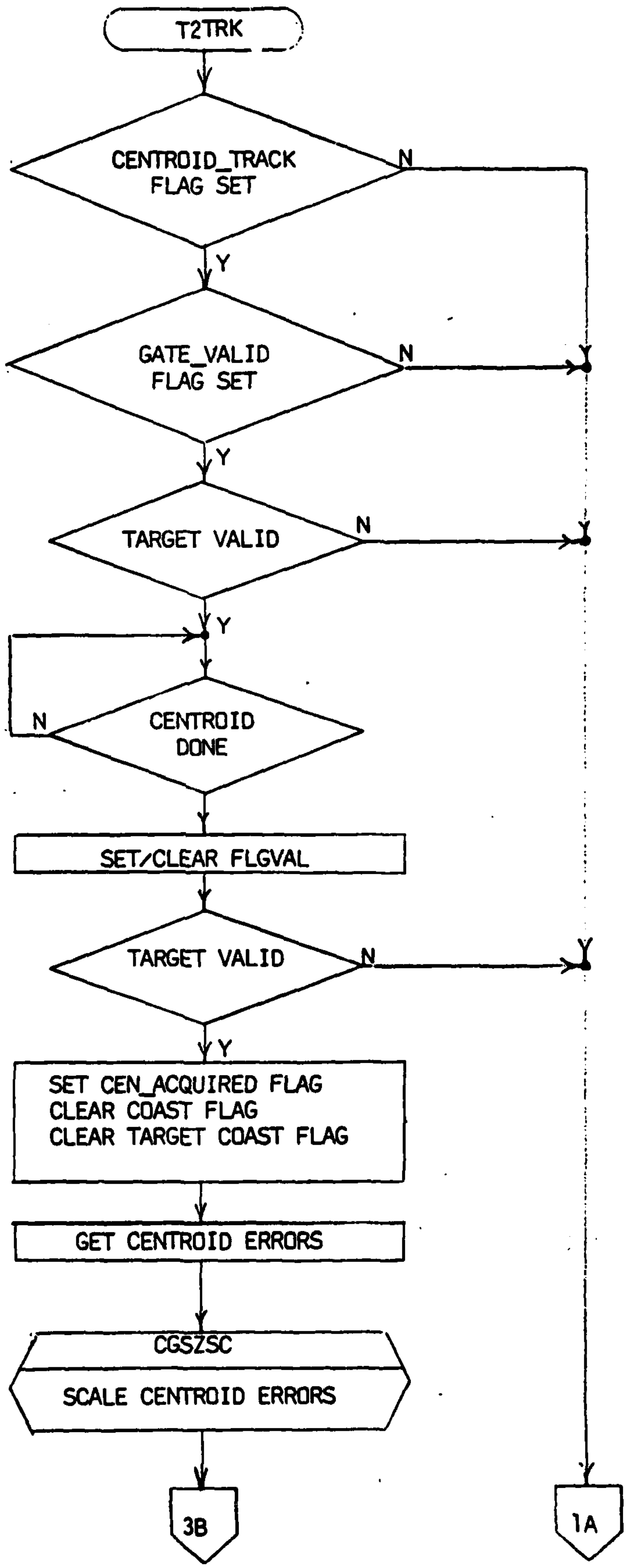

7
N
CENTROID TRACK
SET CENTROID TRACK FLAG
TURN OFF ALARM
AZ-ERROR > AZ-GUN-CIM
TURN ON ALARM
SET AZ-LIMIT-EXCEEDING FLAG
EL-ERROR > EL-GUN-LIMIT
TURN ON ALARM
SET EL-LIMIT-EXCEEDED FLAG
MERGE THE FOLLOWING DATA INTO 2 SERIAL DATA LINK FLAGS WORD
FLAGS-WORD-1 = (ACQUISITION, REF-TRACKABLE, OFFSET-TRK, FOV-CHANGE, BORESIGHT-LOCKED-UP, REF-INDICATOR, COAST) FLAG
FLAGS-WORD-2 = (MODE-WRAP-BACK, CENTROID TRACK, AZ-LIMIT-EXCEEDED, EL-LIMIT-EXCEEDED) FLAG
SDLINK
INTERRUPT DRIVEN SERIAL DATA LINK
HALT

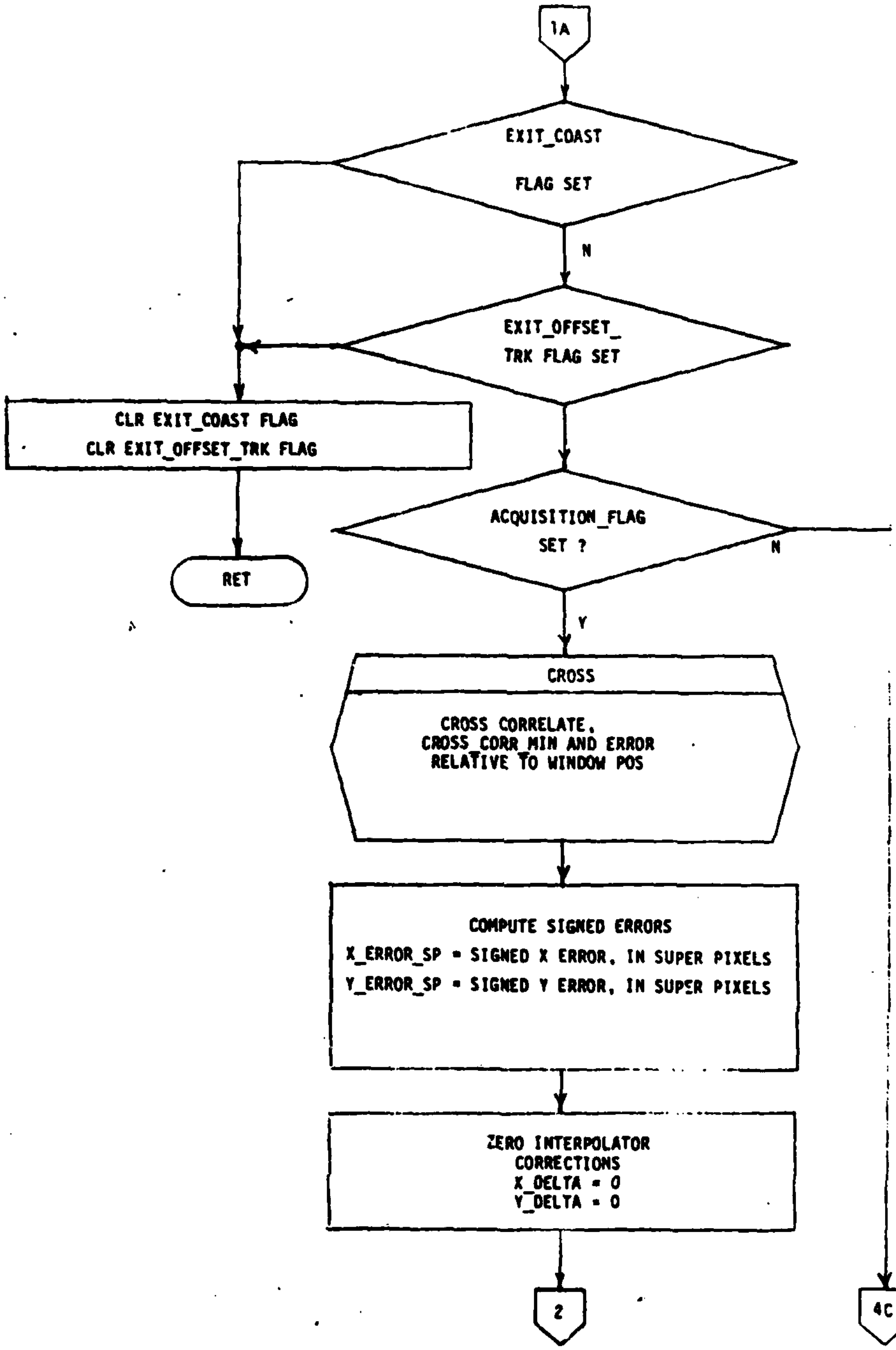

SDLINK
FORM SERIAL DATA LINK
WORD STACK
AZ_ERROR
EL_ERROR
FLAGS_WORD_1
FLAGS_WORD_2
CHECK_SUM
TURN ON SERIAL DATA
LINK TRANSMITTER
OUTPUT MARKING DATA
FROM μp SOD PIN
INITIALIZE
WORD COUNT = 7
XMIT
SEND 1st WORD TO THE
CONTROL STATION
RET

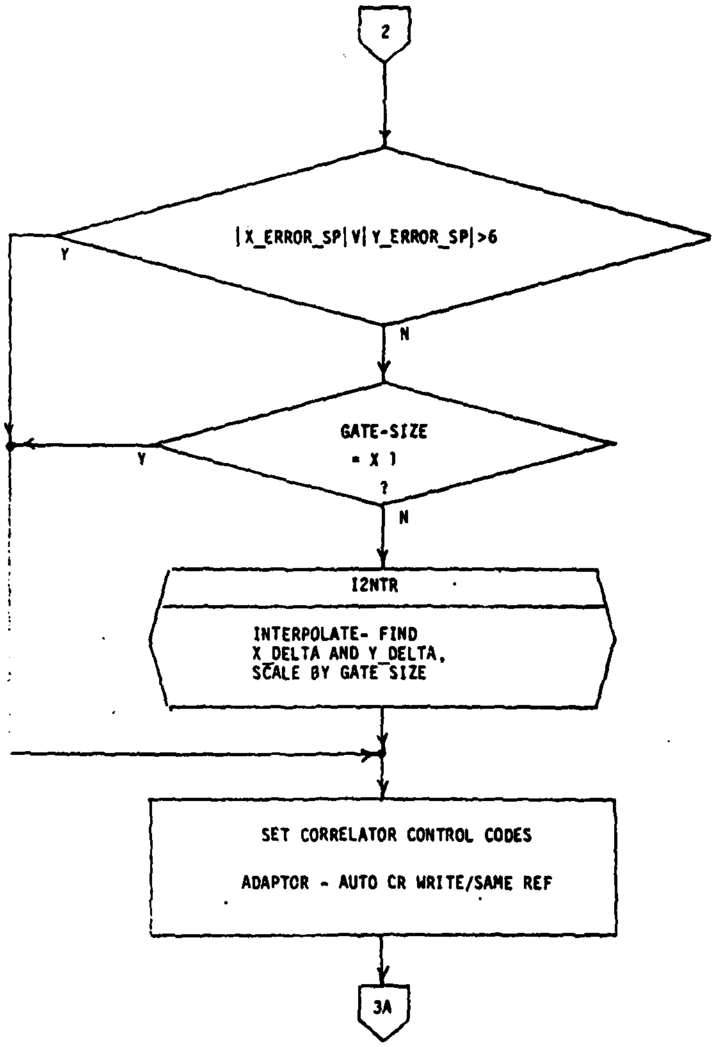

TITRK
SET/CLEAR FLGVAL
AUTO_TRACK FLAG SET
N
Y
CENTROID_TRACK FLAG SET
N
Y
CLEAR GATE_VALID FLAG
CLEAR CEN_ACQUIRED FLAG
B1
GATE_VALID FLAG SET
Y
N
GATE_SIZE = 1X
COAST FLAG SET
N
Y
TICFOV
LET SP SELECT GATE SIZE
CEN_ACQUIRED
Y
N
GATSZ <4
N
Y
TICFOV
LET SP SELECT GATE SIZE
B1

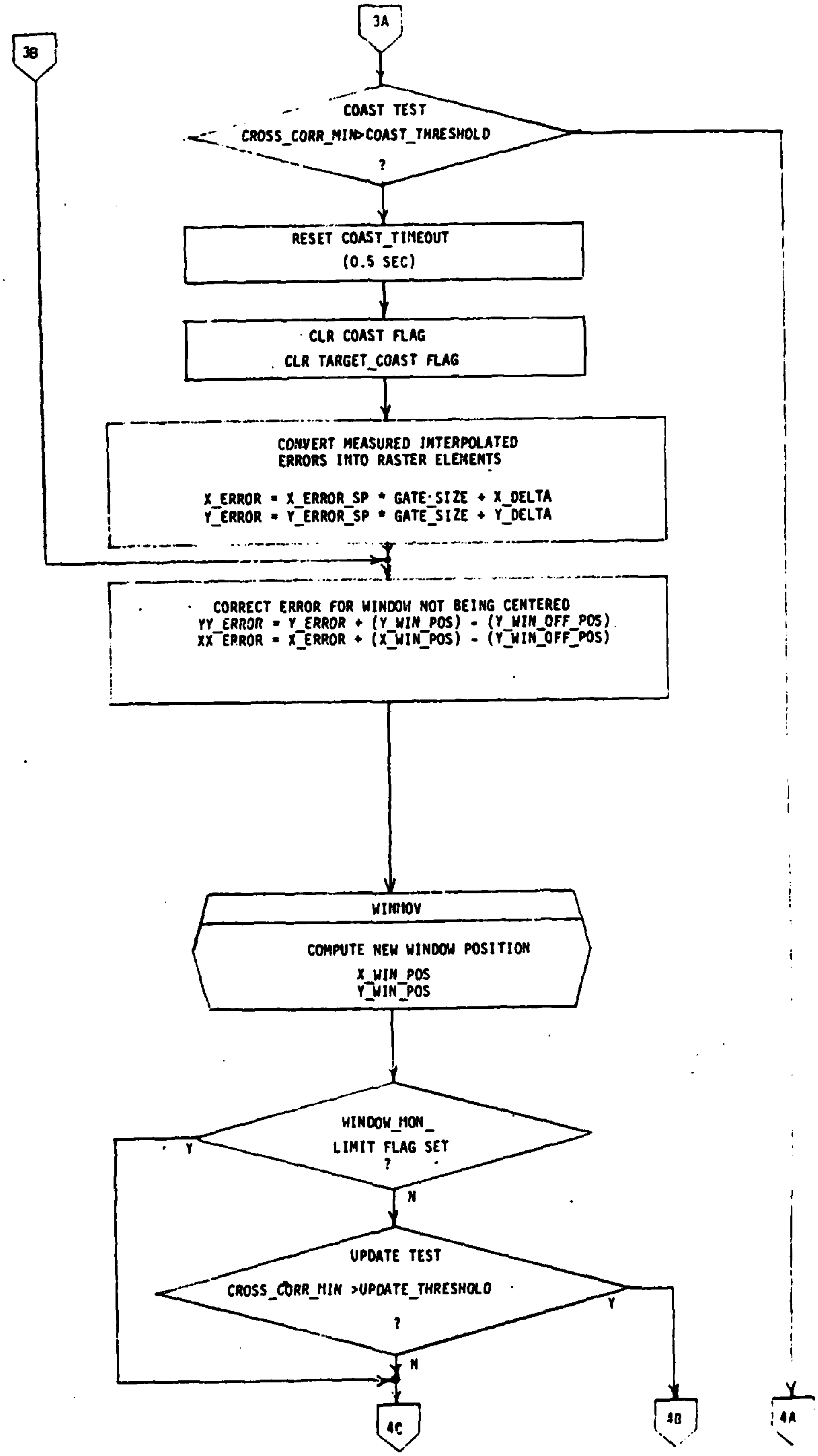

B1
FIELD-OF-VIEW CHANGE FROM PRECEEDING FRAME
SET FOV - CHANGE FLAG
CLEAR ACQUISITION FLAG
OUTPUT NEW FIELD OF VIEW COMMAND TO OPTICS
LOAD FOV - INDEX
FOV - INDEX = (0,1,...5) FOR
FIELD OF VIEW = (0.65°, 1.35°,...10°)
OUTPUT EXISTING FOV COMMAND TO OPTICS
LOAD CENTER WINDOW POSITION
X-WIN-POS = X-WIN-CENTER
Y-WIN-POS = Y-WIN-CENTER
X-WIN-OFF = X-WIN-CENTER
Y-WIN-OFF = Y-WIN-CENTER
FOV-CHANGE FLAG SET
DEC FOV-CHG-TIMEOUT
FOV-CHG. TIMEOUT = φ
CLEAR FOV-CHANGE FLAG
RESET FOV-CHG. TIMEOUT = 0.5sec.
2

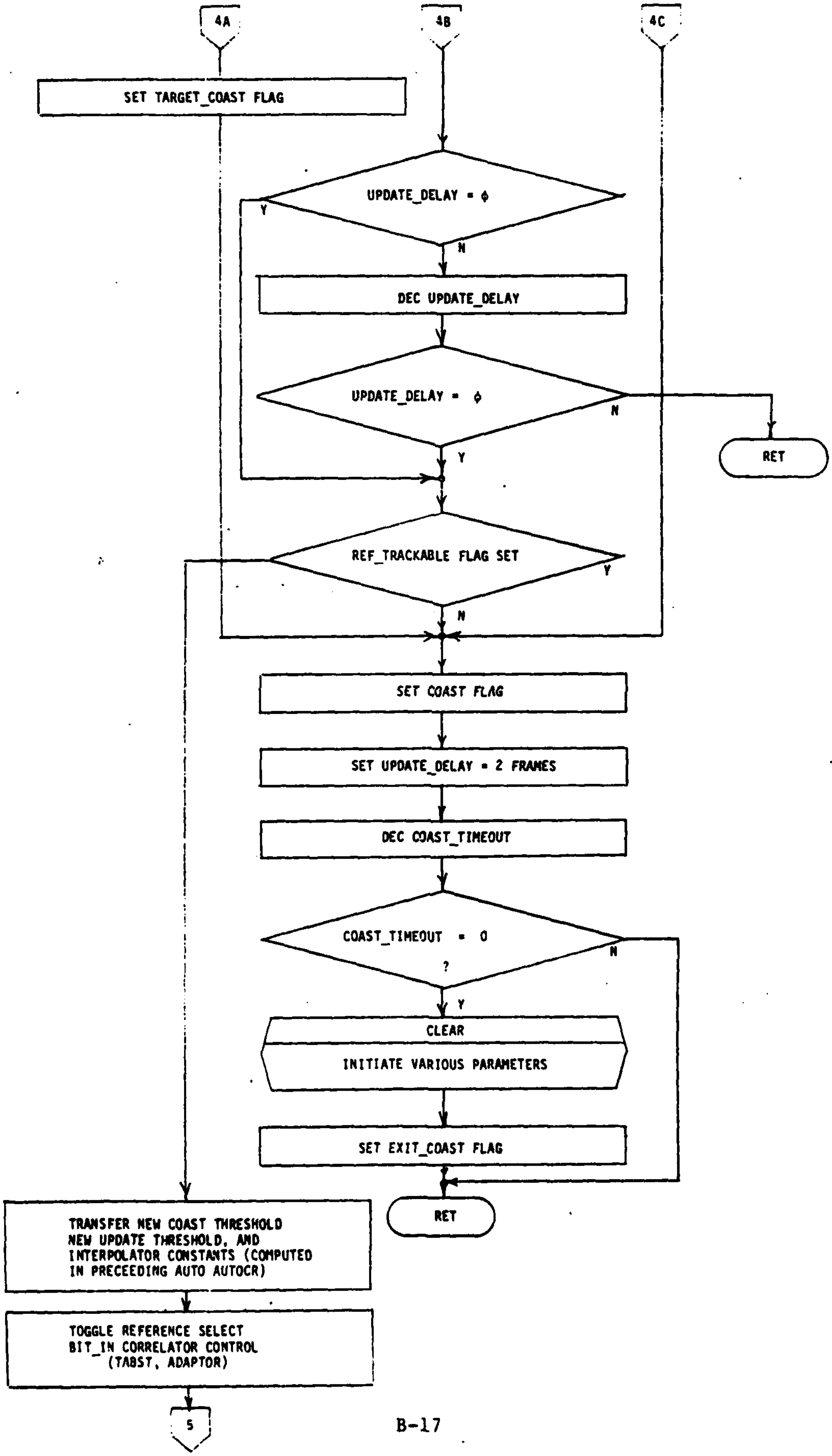

2
AUTO_TRACK FLAG SET
Y
N
DETERMINE GATE SIZE FROM MANUAL COMMAND
GATE-SIZE CHANGE FROM PRECEEDING FRAME
COMPUTE NEW WINDOW POSITION
X-WIN-POS(n) = X-WIN-POS(n-1)+ GATE-SIZE(n-1)-GATE-SIZE(n) *16
Y-WIN-POS(n) = Y-WIN-POS(n-1)+ GATE-SIZE(n-1)-GATE-SIZE(n) *16
X-WIN-OFF-POS = X-WIN-POS
Y-WIN-OFF-POS = Y-WIN-POS
SET GATES - CHANGE FLAG
SET CORRELATOR CONTROL COPES TO TAKE A NEW REFERENCE
TABST = CROSS CORR/LEFT REF
ADATAR = WRITE BOTH REFERENCES
LOAD NEW GATE SIZE DEPENDENT PARAMETERS
CENTER WINDOW POS, X & Y WINDOW POSITION LIMITS, TRACKABILITY THRESHOLD
LIMIT NEW WINDOW POSITION
CLR ACQUISITION FLAG
RET

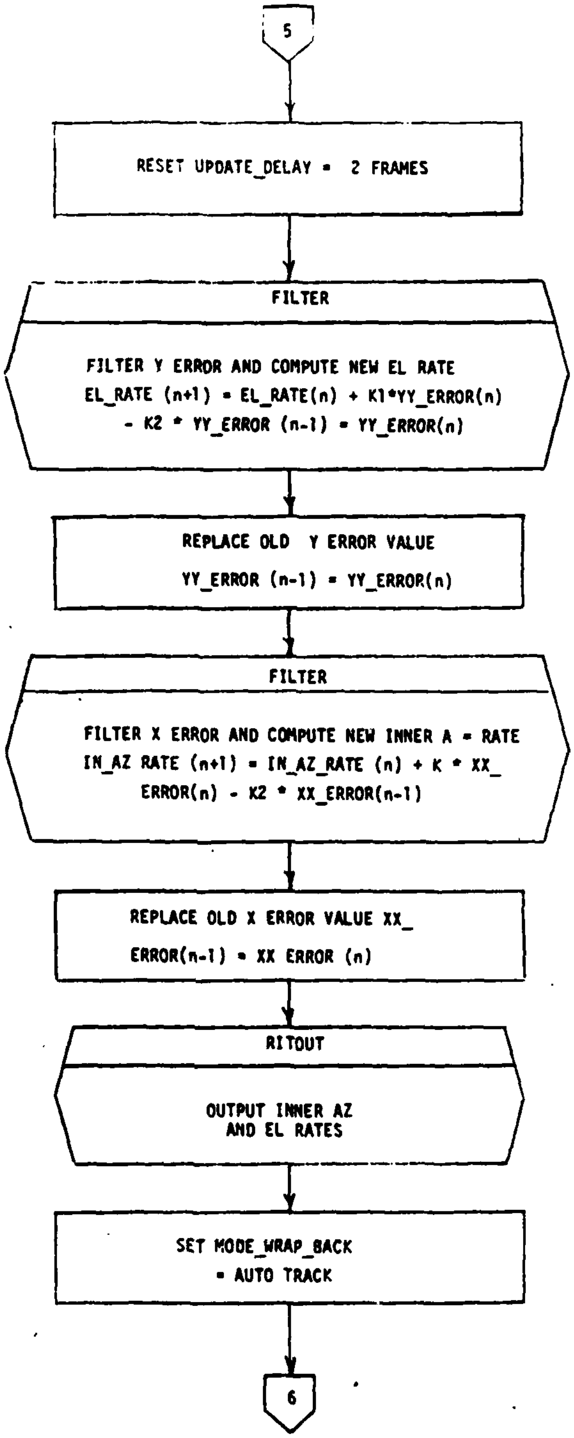

T2TRK
CENTROID_TRACK FLAG SET
N
Y
GATE_VALID FLAG SET
N
Y
TARGET VALID
N
Y
CENTROID DONE
N
SET/CLEAR FLGVAL
TARGET VALID
N
Y
SET CEN_ACQUIRED FLAG
CLEAR COAST FLAG
CLEAR TARGET COAST FLAG
GET CENTROID ERRORS
CGSZSC
SCALE CENTROID ERRORS
3B
1A

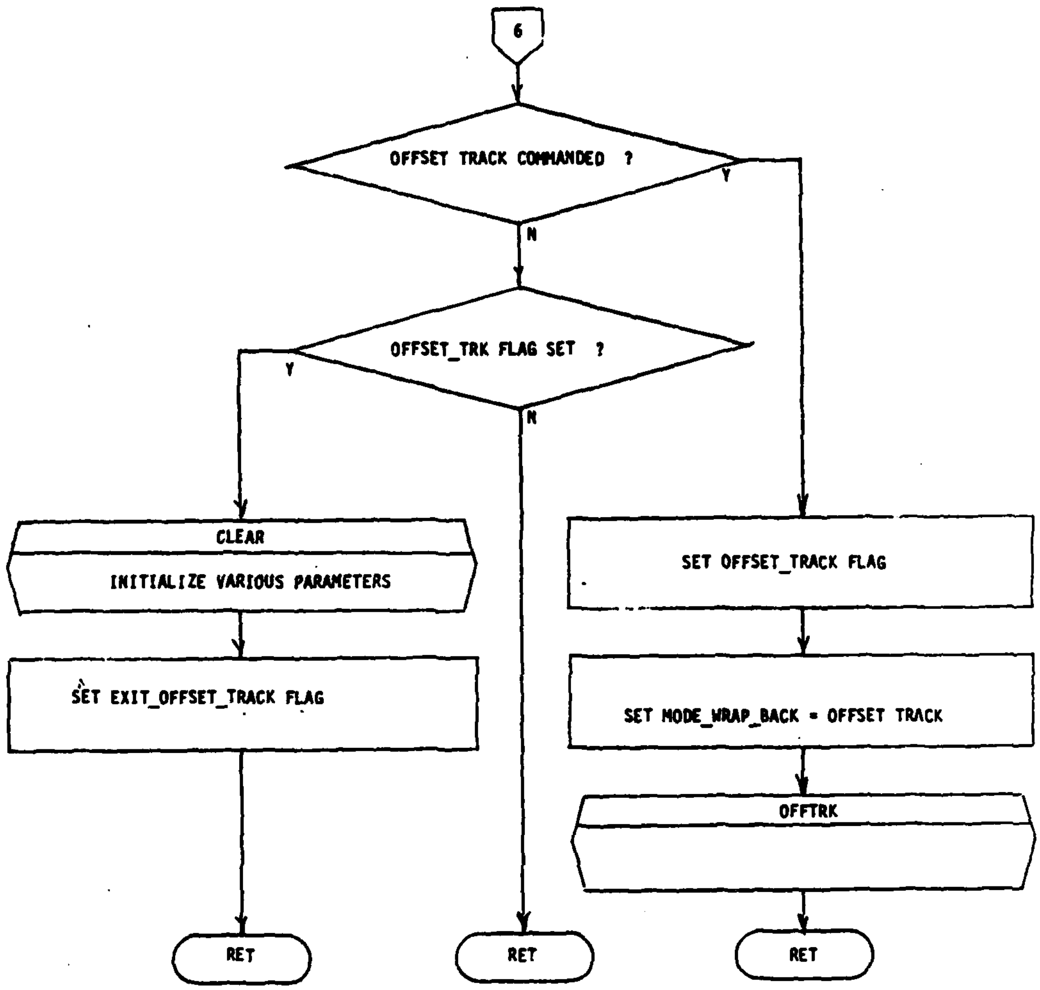

1A
EXIT_COAST
FLAG SET
N
EXIT_OFFSET_
TRK FLAG SET
CLR EXIT_COAST FLAG
CLR EXIT_OFFSET_TRK FLAG
RET
ACQUISITION_FLAG
SET ?
N
Y
CROSS
CROSS CORRELATE,
CROSS_CORR_MIN AND ERROR
RELATIVE TO WINDOW POS
COMPUTE SIGNED ERRORS
X_ERROR_SP = SIGNED X ERROR, IN SUPER PIXELS
Y_ERROR_SP = SIGNED Y ERROR, IN SUPER PIXELS
ZERO INTERPOLATOR
CORRECTIONS
X_DELTA = 0
Y_DELTA = 0
2
4C


2
|X_ERROR_SP| V |Y_ERROR_SP|>6
Y
N
GATE-SIZE
= X 1
?
Y
N
I2NTR
INTERPOLATE- FIND
X_DELTA AND Y_DELTA,
SCALE BY GATE SIZE
SET CORRELATOR CONTROL CODES
ADAPTOR - AUTO CR WRITE/SAME REF
3A

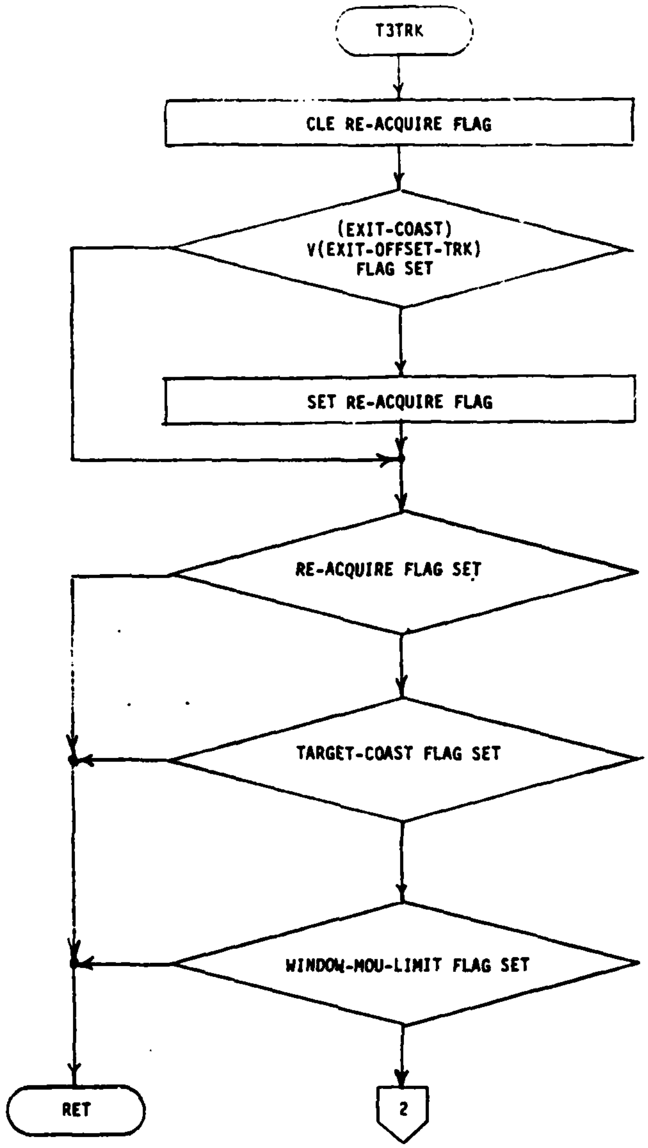

3A
3B
COAST TEST
CROSS_CORR_MIN>COAST_THRESHOLD
?
RESET COAST_TIMEOUT
(0.5 SEC)
CLR COAST FLAG
CLR TARGET_COAST FLAG
CONVERT MEASURED INTERPOLATED
ERRORS INTO RASTER ELEMENTS
X_ERROR = X_ERROR_SP * GATE_SIZE + X_DELTA
Y_ERROR = Y_ERROR_SP * GATE_SIZE + Y_DELTA
CORRECT ERROR FOR WINDOW NOT BEING CENTERED
YY_ERROR = Y_ERROR + (Y_WIN_POS) - (Y_WIN_OFF_POS)
XX_ERROR = X_ERROR + (X_WIN_POS) - (Y_WIN_OFF_POS)
WINMOV
COMPUTE NEW WINDOW POSITION
X_WIN_POS
Y_WIN_POS
WINDOW_MON_
LIMIT FLAG SET
?
Y
N
UPDATE TEST
CROSS_CORR_MIN >UPDATE_THRESHOLD
?
Y
N
4C
4B
4A

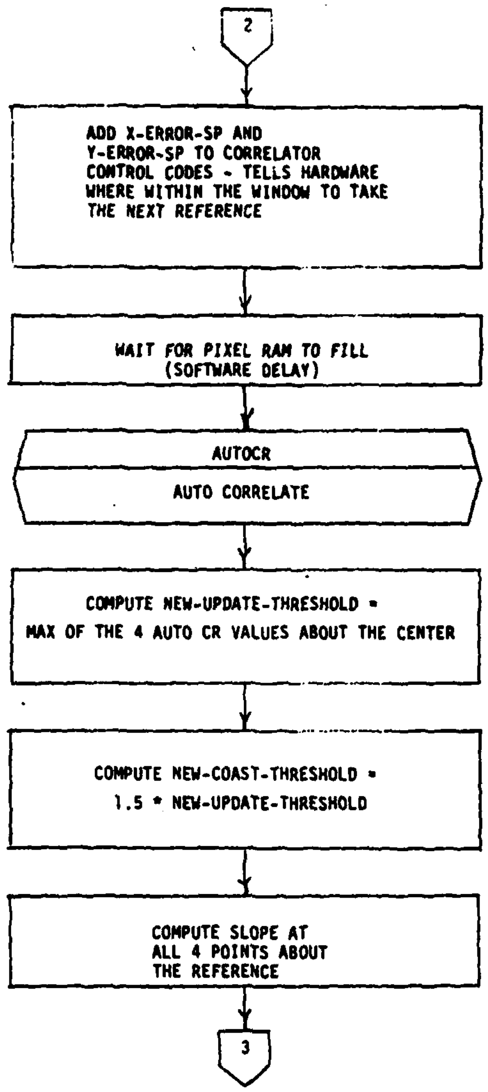

4A
4B
4C
SET TARGET_COAST FLAG
UPDATE_DELAY = ϕ
Y
N
DEC UPDATE_DELAY
UPDATE_DELAY = ϕ
N
RET
Y
REF_TRACKABLE FLAG SET
Y
N
SET COAST FLAG
SET UPDATE_DELAY = 2 FRAMES
DEC COAST_TIMEOUT
COAST_TIMEOUT = 0
?
N
Y
CLEAR
INITIATE VARIOUS PARAMETERS
SET EXIT_COAST FLAG
RET
TRANSFER NEW COAST THRESHOLD
NEW UPDATE THRESHOLD, AND
INTERPOLATOR CONSTANTS (COMPUTED
IN PRECEEDING AUTO AUTOCR)
TOGGLE REFERENCE SELECT
BIT_IN CORRELATOR CONTROL
(TABST, ADAPTOR)
5

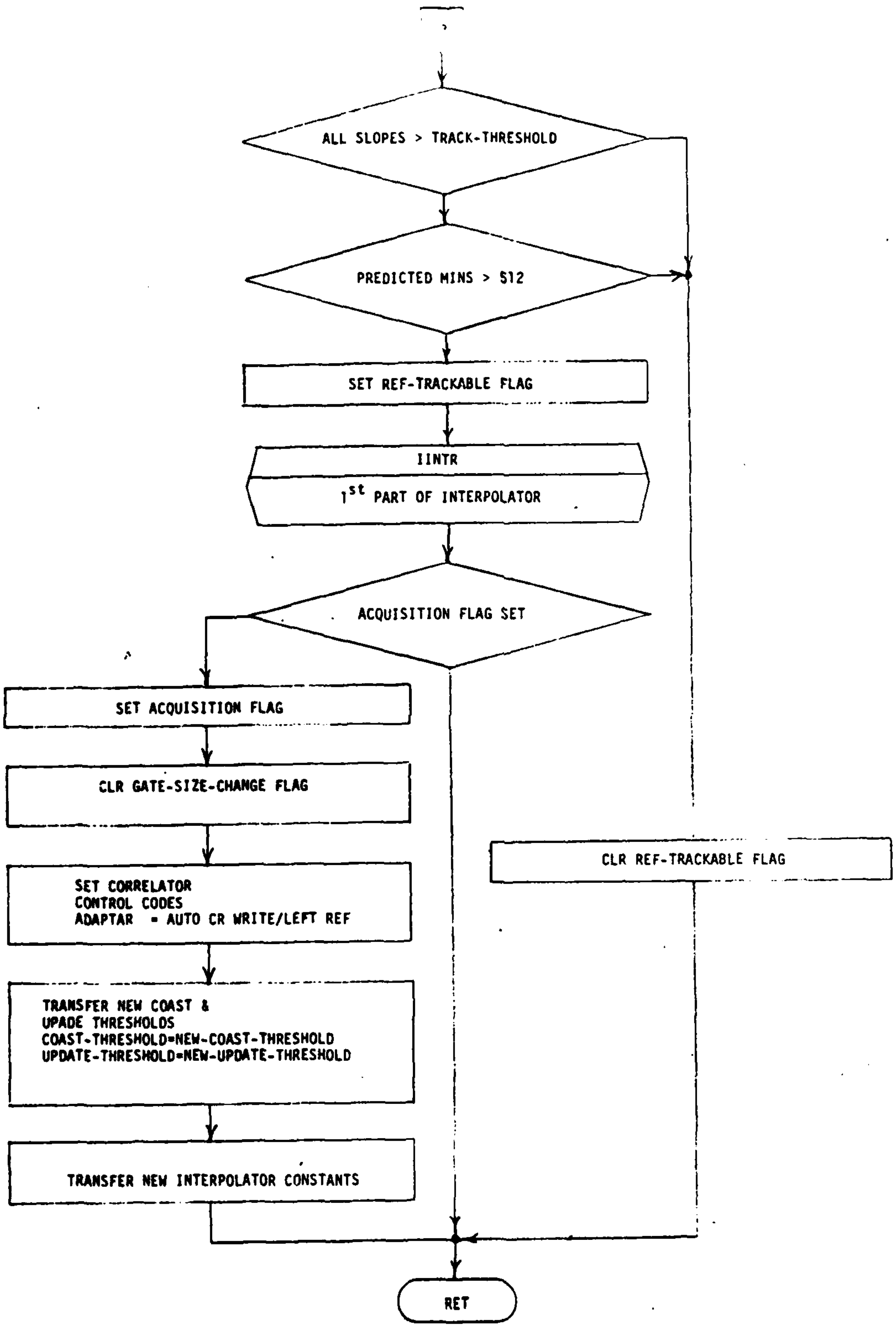

5
RESET UPDATE_DELAY = 2 FRAMES
FILTER
FILTER Y ERROR AND COMPUTE NEW EL RATE
EL_RATE (n+1) = EL_RATE(n) + K1*YY_ERROR(n)
- K2 * YY_ERROR (n-1) = YY_ERROR(n)
REPLACE OLD Y ERROR VALUE
YY_ERROR (n-1) = YY_ERROR(n)
FILTER
FILTER X ERROR AND COMPUTE NEW INNER A = RATE
IN_AZ RATE (n+1) = IN_AZ_RATE (n) + K * XX_
ERROR(n) - K2 * XX_ERROR(n-1)
REPLACE OLD X ERROR VALUE XX_
ERROR(n-1) = XX ERROR (n)
RITOUT
OUTPUT INNER AZ
AND EL RATES
SET MODE_WRAP_BACK
= AUTO TRACK
6

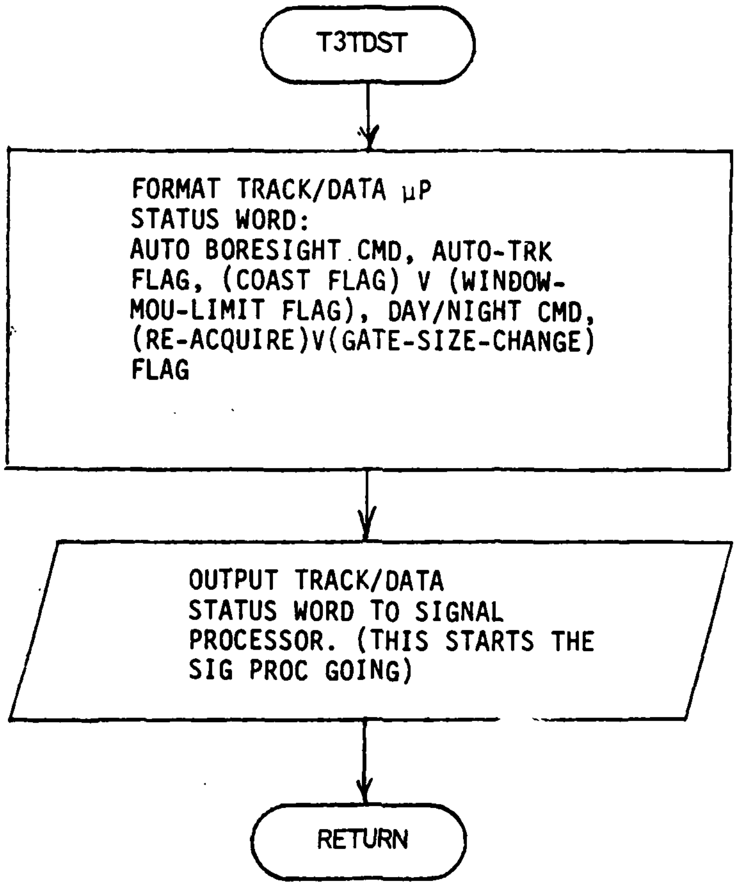


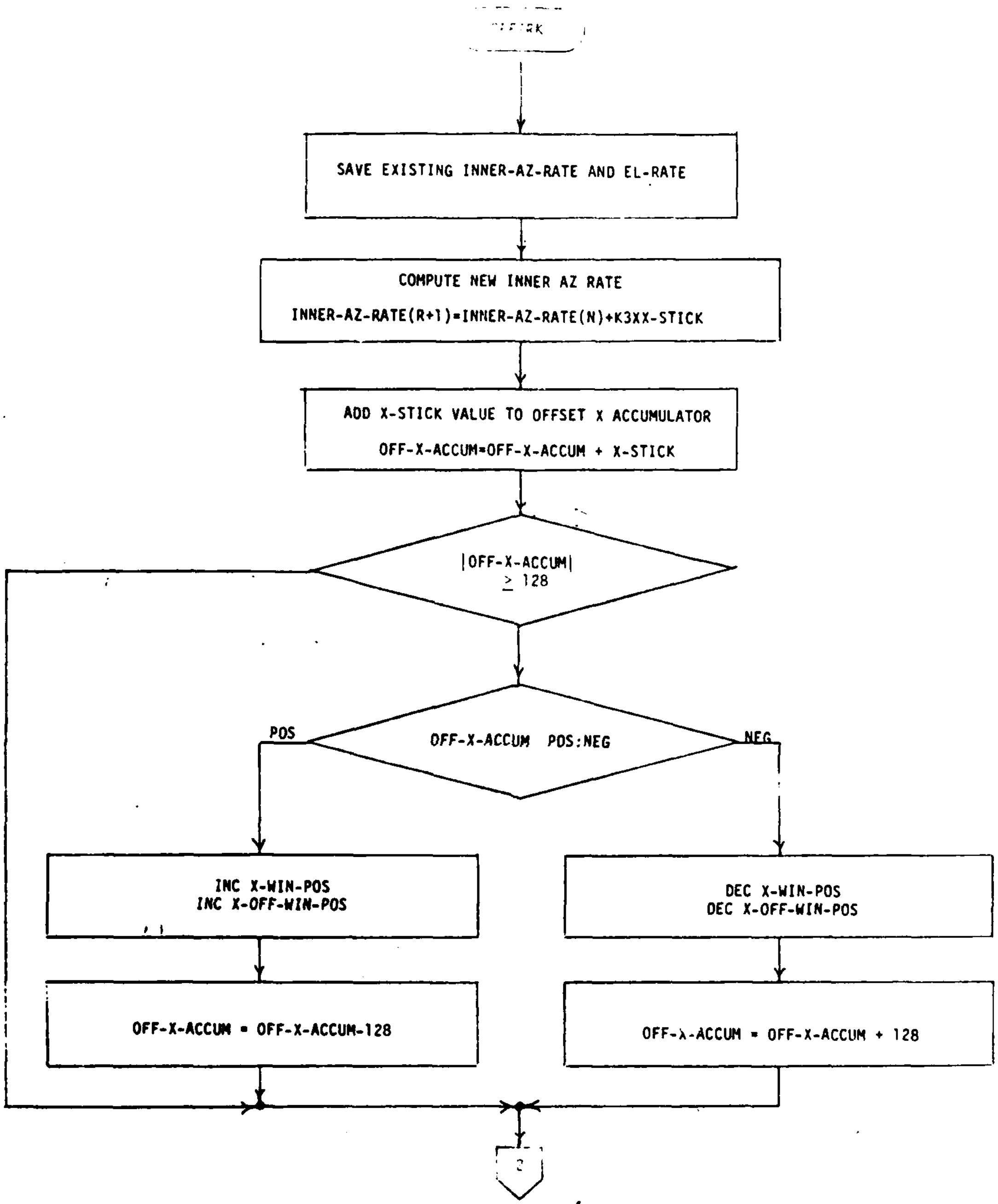
6
OFFSET TRACK COMMANDED ?
Y
N
OFFSET_TRK FLAG SET ?
Y
N
CLEAR
INITIALIZE VARIOUS PARAMETERS
SET EXIT_OFFSET_TRACK FLAG
SET OFFSET_TRACK FLAG
SET MODE_WRAP_BACK = OFFSET TRACK
OFFTRK
RET
RET
RET


T3TRK
CLE RE-ACQUIRE FLAG
(EXIT-COAST)
V(EXIT-OFFSET-TRK)
FLAG SET
SET RE-ACQUIRE FLAG
RE-ACQUIRE FLAG SET
TARGET-COAST FLAG SET
WINDOW-MOU-LIMIT FLAG SET
RET
2


2
ADD X-ERROR-SP AND Y-ERROR-SP TO CORRELATOR CONTROL CODES - TELLS HARDWARE WHERE WITHIN THE WINDOW TO TAKE THE NEXT REFERENCE
WAIT FOR PIXEL RAM TO FILL (SOFTWARE DELAY)
AUTOCR
AUTO CORRELATE
COMPUTE NEW-UPDATE-THRESHOLD =
MAX OF THE 4 AUTO CR VALUES ABOUT THE CENTER
COMPUTE NEW-COAST-THRESHOLD =
1.5 * NEW-UPDATE-THRESHOLD
COMPUTE SLOPE AT ALL 4 POINTS ABOUT THE REFERENCE
3


ALL SLOPES > TRACK-THRESHOLD
PREDICTED MINS > 512
SET REF-TRACKABLE FLAG
IINTR
1st PART OF INTERPOLATOR
ACQUISITION FLAG SET
SET ACQUISITION FLAG
CLR GATE-SIZE-CHANGE FLAG
SET CORRELATOR
CONTROL CODES
ADAPTAR = AUTO CR WRITE/LEFT REF
TRANSFER NEW COAST &
UPADE THRESHOLDS
COAST-THRESHOLD=NEW-COAST-THRESHOLD
UPDATE-THRESHOLD=NEW-UPDATE-THRESHOLD
TRANSFER NEW INTERPOLATOR CONSTANTS
CLR REF-TRACKABLE FLAG
RET

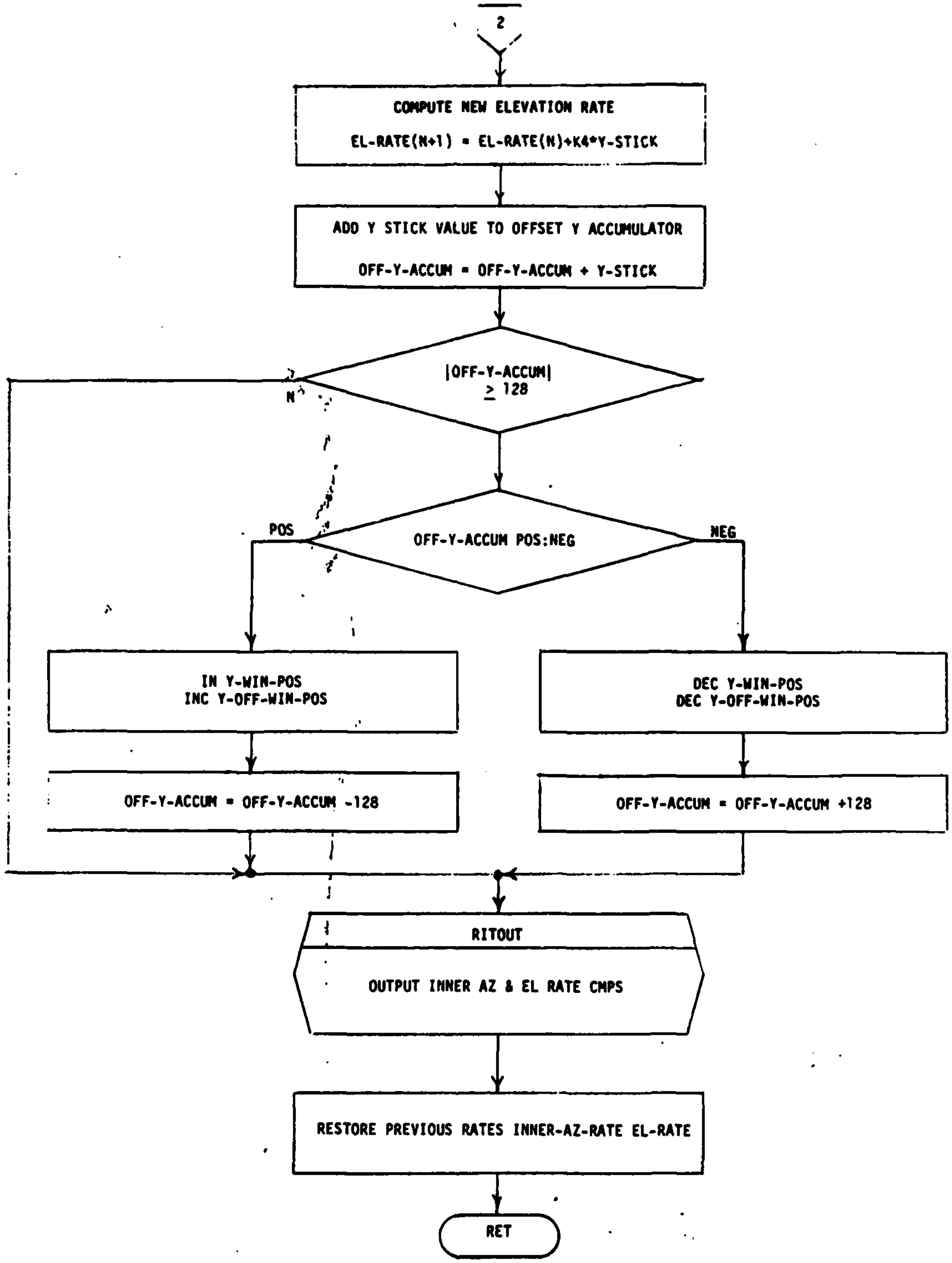

T3TDST
FORMAT TRACK/DATA µP
STATUS WORD:
AUTO BORESIGHT CMD, AUTO-TRK
FLAG, (COAST FLAG) V (WINDOW-
MOU-LIMIT FLAG), DAY/NIGHT CMD,
(RE-ACQUIRE)V(GATE-SIZE-CHANGE)
FLAG
OUTPUT TRACK/DATA
STATUS WORD TO SIGNAL
PROCESSOR. (THIS STARTS THE
SIG PROC GOING)
RETURN

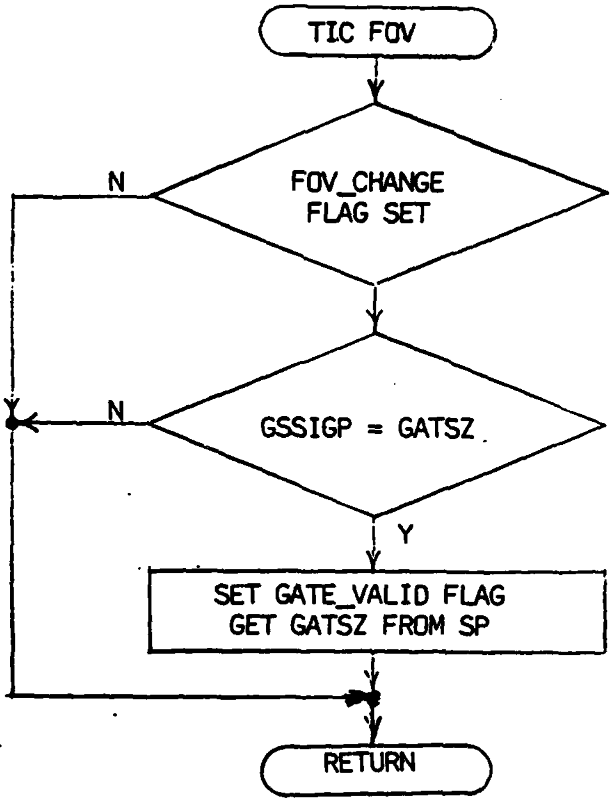

SAVE EXISTING INNER-AZ-RATE AND EL-RATE
COMPUTE NEW INNER AZ RATE
INNER-AZ-RATE(R+1)=INNER-AZ-RATE(N)+K3XX-STICK
ADD X-STICK VALUE TO OFFSET X ACCUMULATOR
OFF-X-ACCUM=OFF-X-ACCUM + X-STICK
|OFF-X-ACCUM| ≥ 128
OFF-X-ACCUM POS:NEG
POS
NEG
INC X-WIN-POS
INC X-OFF-WIN-POS
DEC X-WIN-POS
DEC X-OFF-WIN-POS
OFF-X-ACCUM = OFF-X-ACCUM-128
OFF-X-ACCUM = OFF-X-ACCUM + 128
2

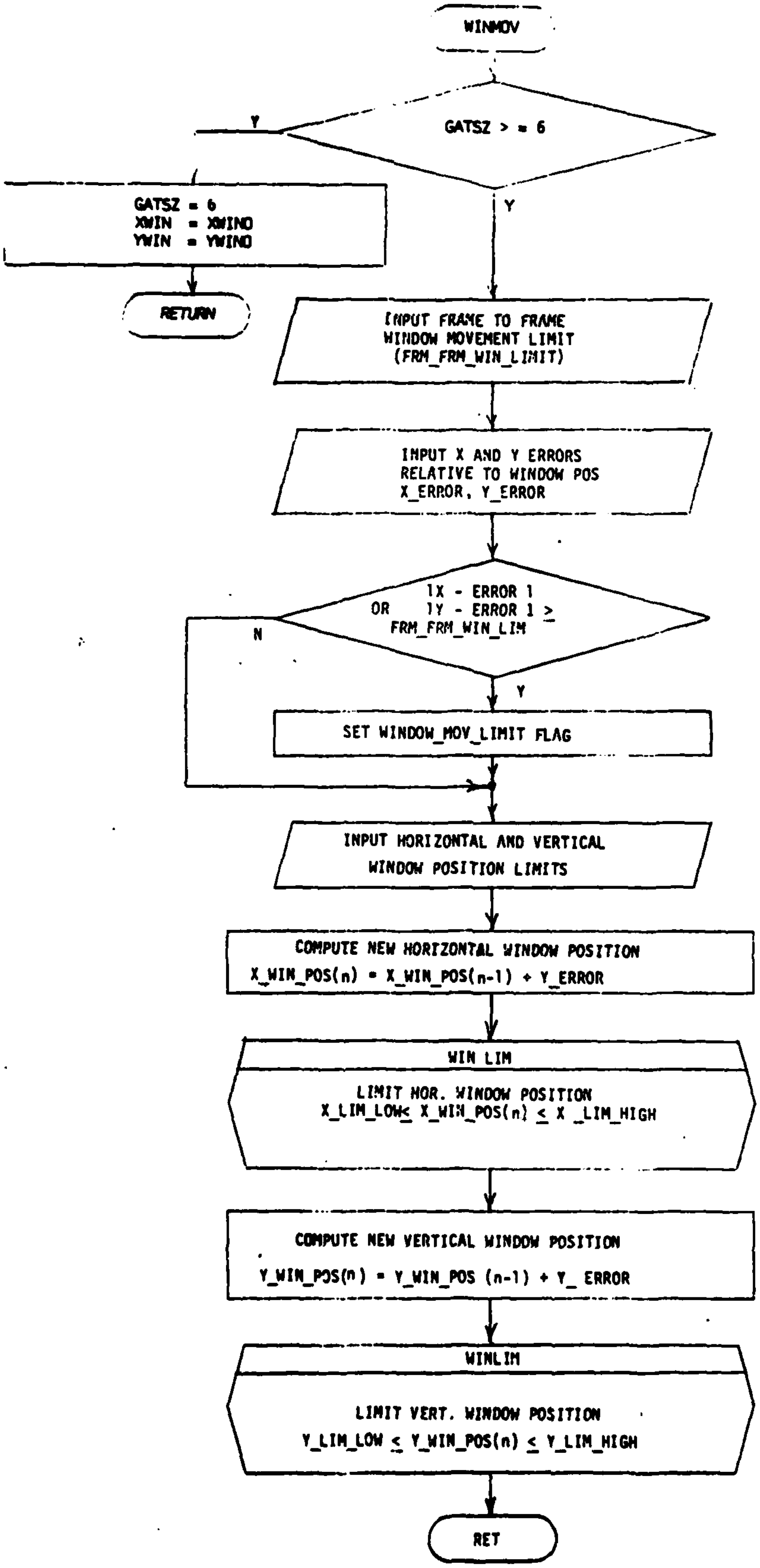
AD-A119 261 ABERDEEN PROVING GROUND MD MATERIEL TESTING DIRECTORATE F/G 19/5
FIRE CONTROL ALL WEATHER (POINTING ANGLE MEASUREMENT SYSTEM (PA--ETC(U)
AUG 82 S F HARLEY, J P SCHIMMINGER
UNCLASSIFIED APG-MT-5672 NL

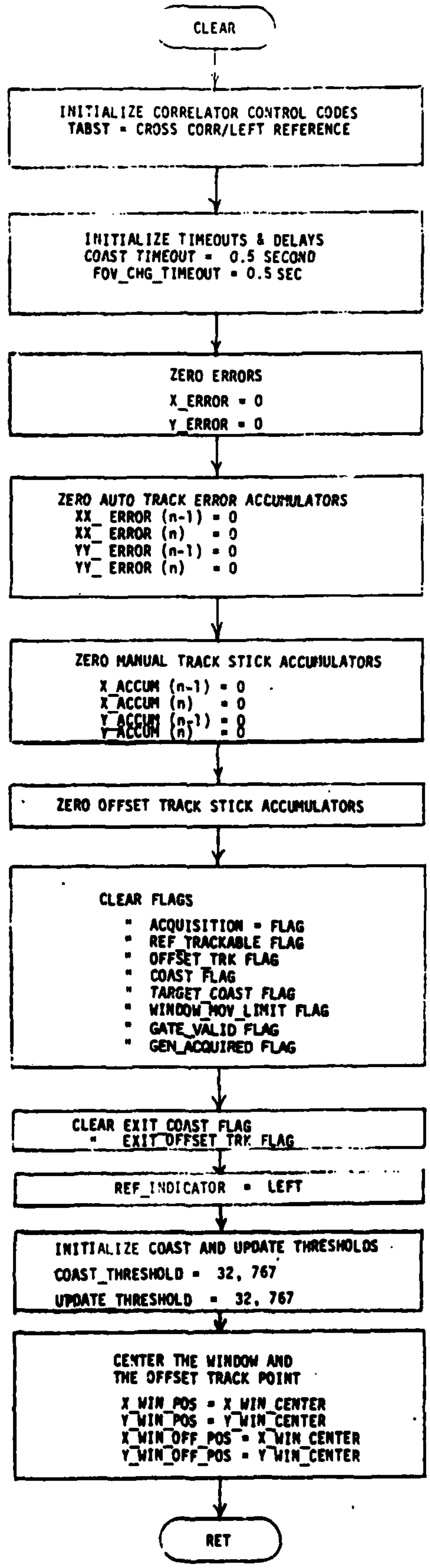
2 OF 2
AD A
119261

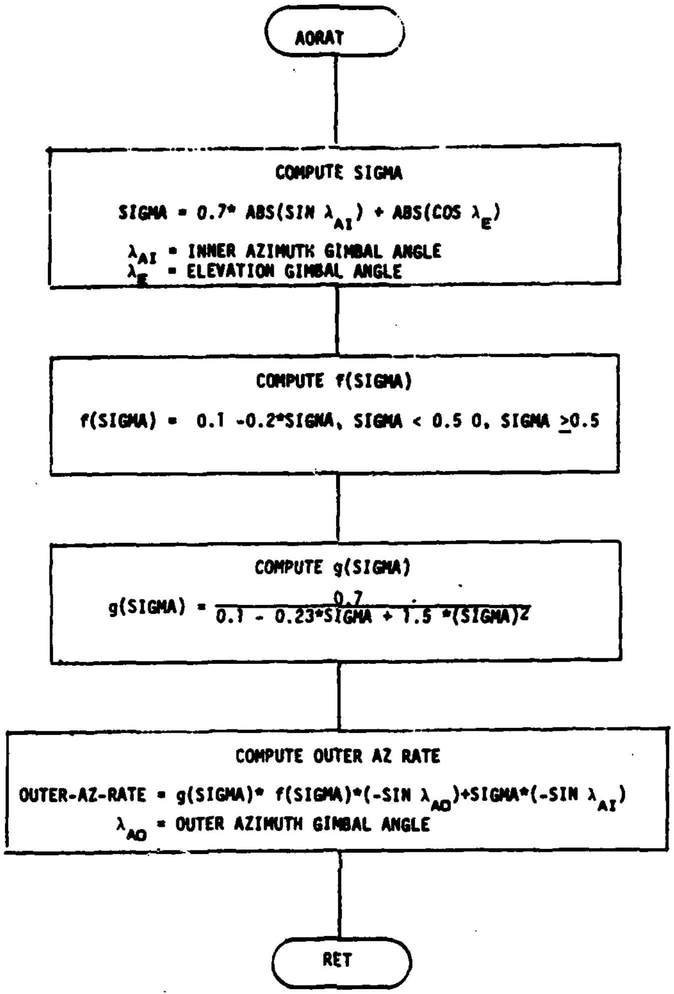
END
DATE
FILMED
10-82
DTIC

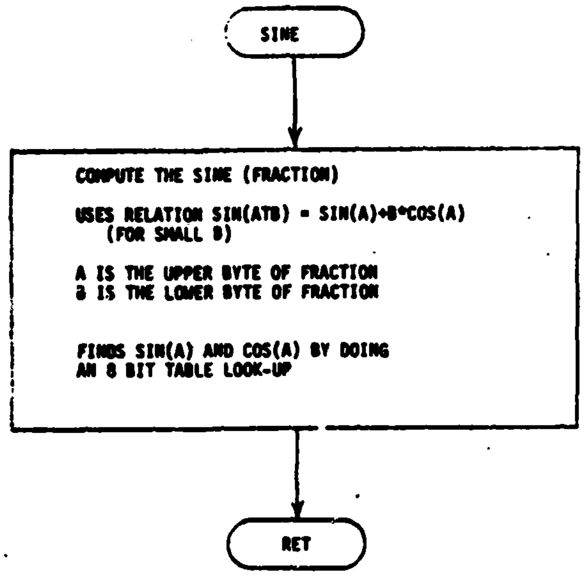

2
COMPUTE NEW ELEVATION RATE
EL-RATE(N+1) = EL-RATE(N)+K4*Y-STICK
ADD Y STICK VALUE TO OFFSET Y ACCUMULATOR
OFF-Y-ACCUM = OFF-Y-ACCUM + Y-STICK
|OFF-Y-ACCUM| ≥ 128
N
OFF-Y-ACCUM POS:NEG
POS
NEG
IN Y-WIN-POS
INC Y-OFF-WIN-POS
DEC Y-WIN-POS
DEC Y-OFF-WIN-POS
OFF-Y-ACCUM = OFF-Y-ACCUM -128
OFF-Y-ACCUM = OFF-Y-ACCUM +128
RITOUT
OUTPUT INNER AZ & EL RATE CMPS
RESTORE PREVIOUS RATES INNER-AZ-RATE EL-RATE
RET

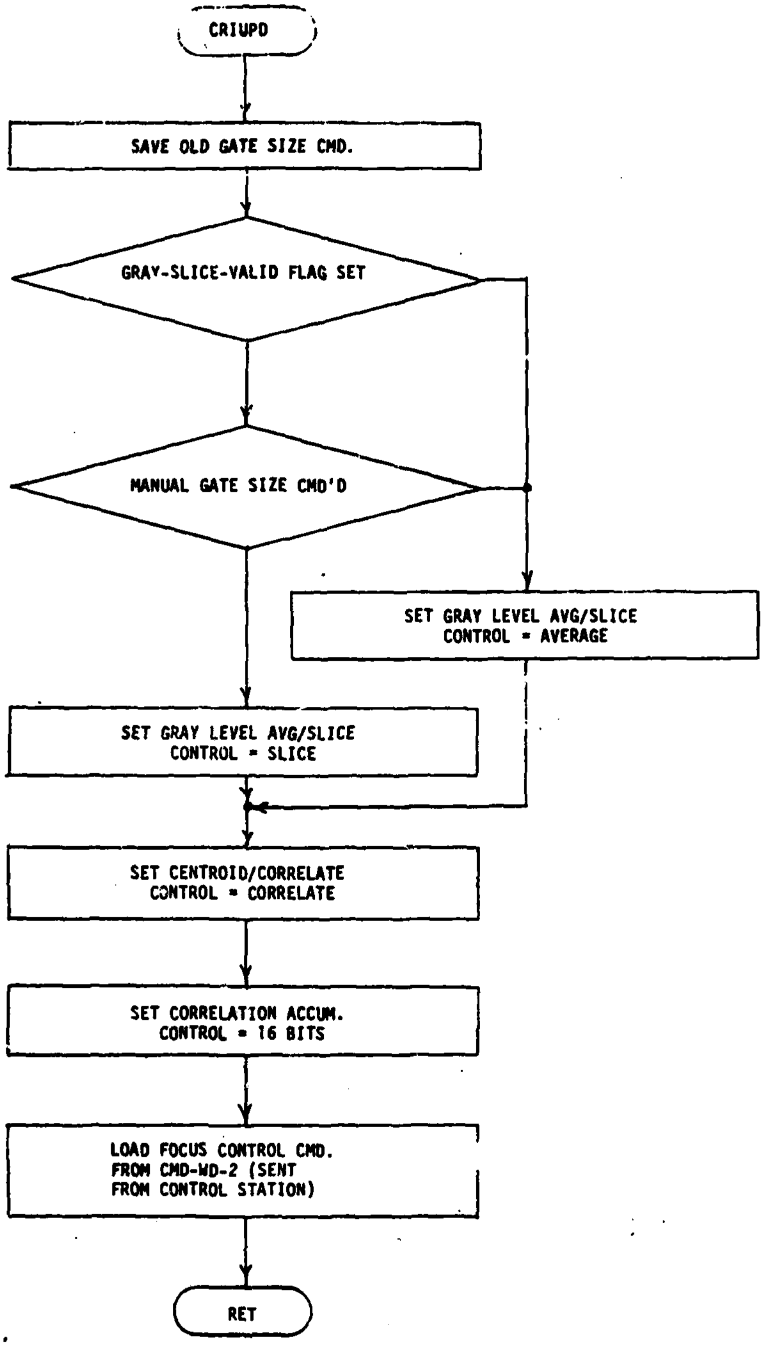

TIC FOV
FOV_CHANGE
FLAG SET
N
GSSIGP = GATSZ
N
Y
SET GATE_VALID FLAG
GET GATSZ FROM SP
RETURN

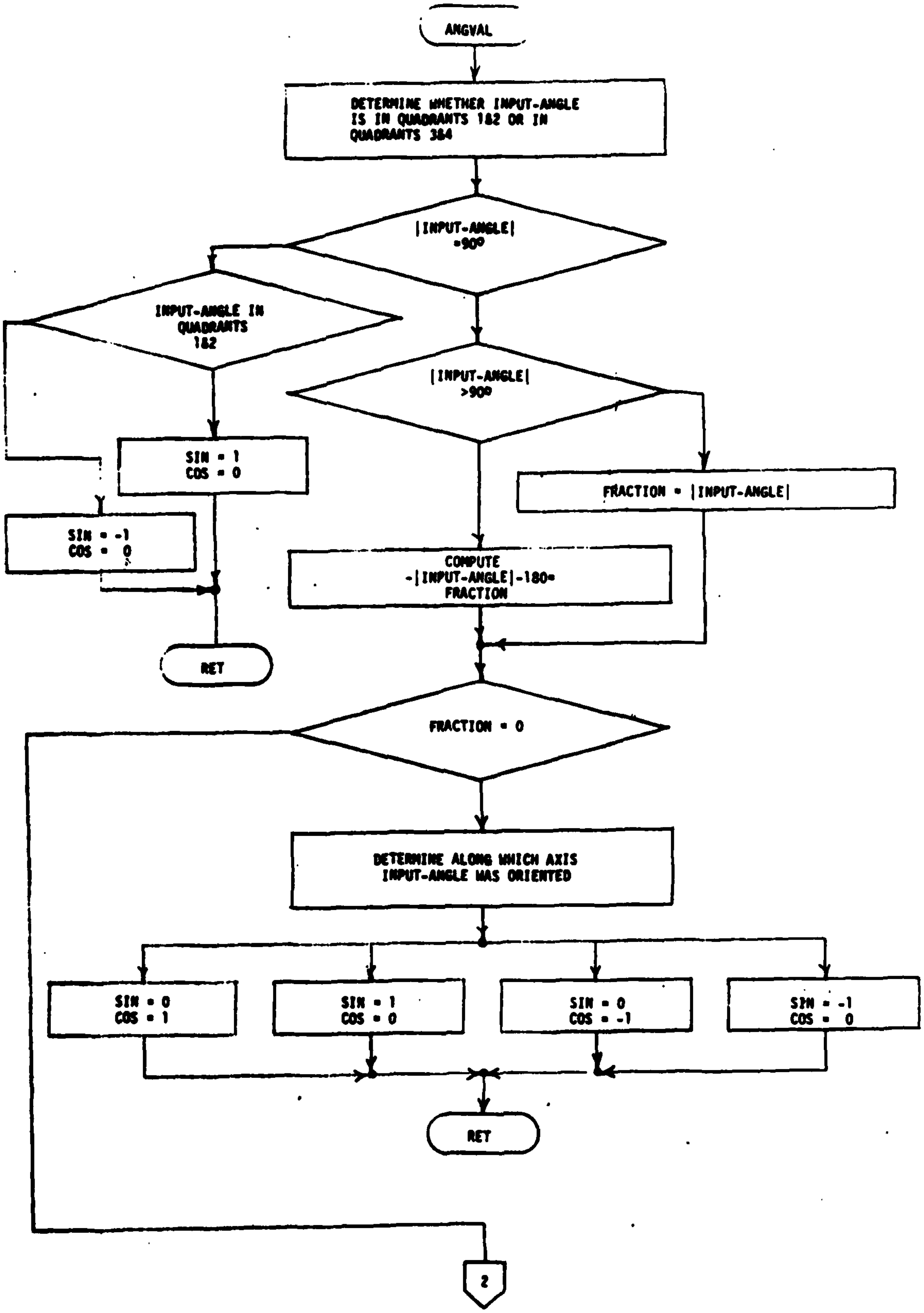

WINMOV
GATSZ > = 6
Y
GATSZ = 6
XWIN = XWINO
YWIN = YWINO
RETURN
Y
INPUT FRAME TO FRAME
WINDOW MOVEMENT LIMIT
(FRM_FRM_WIN_LIMIT)
INPUT X AND Y ERRORS
RELATIVE TO WINDOW POS
X_ERROR, Y_ERROR
1X - ERROR 1
OR 1Y - ERROR 1 ≥
FRM_FRM_WIN_LIM
N
Y
SET WINDOW_MOV_LIMIT FLAG
INPUT HORIZONTAL AND VERTICAL
WINDOW POSITION LIMITS
COMPUTE NEW HORIZONTAL WINDOW POSITION
X_WIN_POS(n) = X_WIN_POS(n-1) + Y_ERROR
WIN LIM
LIMIT HOR. WINDOW POSITION
X_LIM_LOW ≤ X_WIN_POS(n) ≤ X _LIM_HIGH
COMPUTE NEW VERTICAL WINDOW POSITION
Y_WIN_POS(n) = Y_WIN_POS (n-1) + Y_ ERROR
WINLIM
LIMIT VERT. WINDOW POSITION
Y_LIM_LOW ≤ Y_WIN_POS(n) ≤ Y_LIM_HIGH
RET

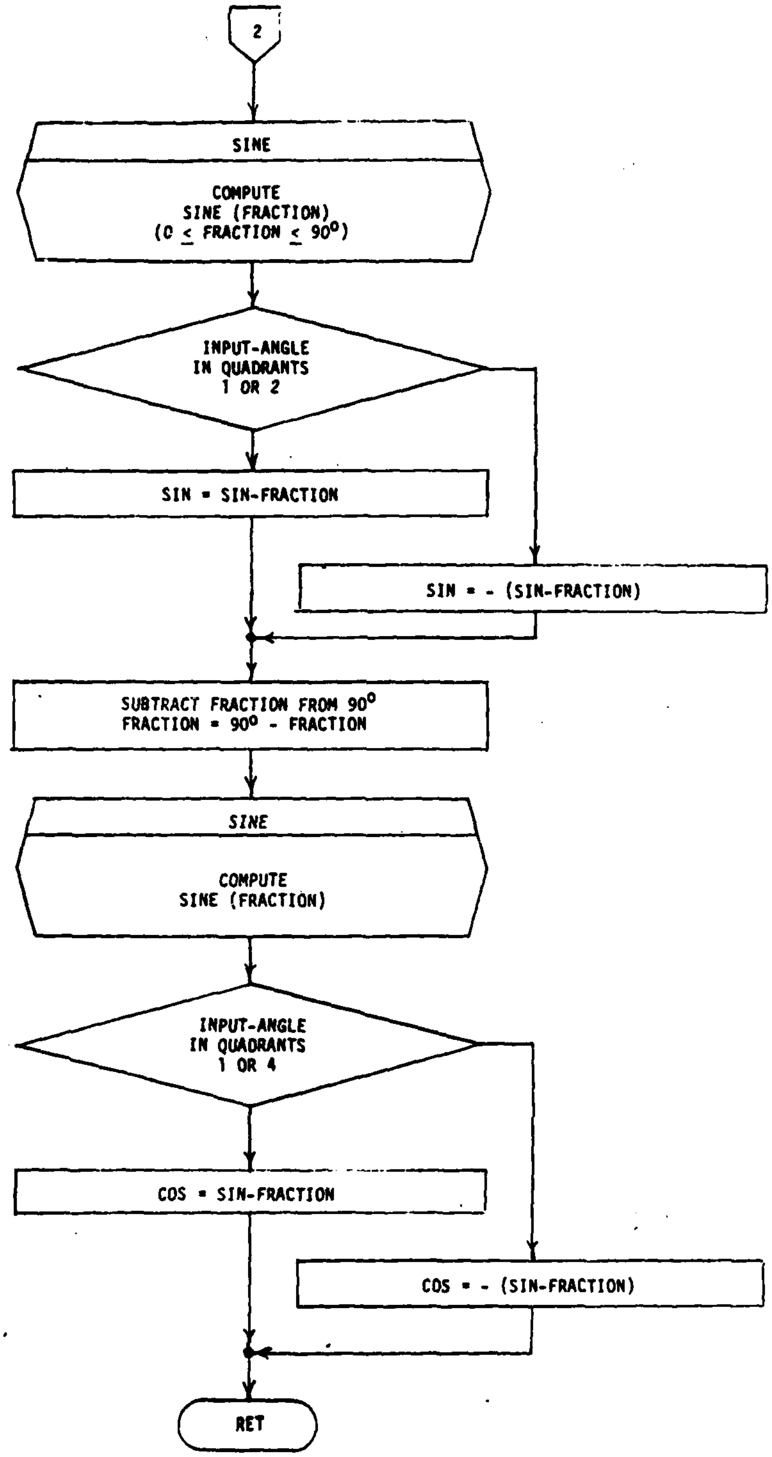

CLEAR
INITIALIZE CORRELATOR CONTROL CODES
TABST = CROSS CORR/LEFT REFERENCE
INITIALIZE TIMEOUTS & DELAYS
COAST TIMEOUT = 0.5 SECOND
FOV_CHG_TIMEOUT = 0.5 SEC
ZERO ERRORS
X_ERROR = 0
Y_ERROR = 0
ZERO AUTO TRACK ERROR ACCUMULATORS
XX_ ERROR (n-1) = 0
XX_ ERROR (n) = 0
YY_ ERROR (n-1) = 0
YY_ ERROR (n) = 0
ZERO MANUAL TRACK STICK ACCUMULATORS
X_ACCUM (n-1) = 0
X_ACCUM (n) = 0
Y_ACCUM (n-1) = 0
Y_ACCUM (n) = 0
ZERO OFFSET TRACK STICK ACCUMULATORS
CLEAR FLAGS
" ACQUISITION = FLAG
" REF_TRACKABLE FLAG
" OFFSET_TRK FLAG
" COAST FLAG
" TARGET_COAST FLAG
" WINDOW_MOV_LIMIT FLAG
" GATE_VALID FLAG
" GEN_ACQUIRED FLAG
CLEAR EXIT_COAST FLAG
" EXIT_OFFSET_TRK FLAG
REF_INDICATOR = LEFT
INITIALIZE COAST AND UPDATE THRESHOLDS
COAST_THRESHOLD = 32, 767
UPDATE_THRESHOLD = 32, 767
CENTER THE WINDOW AND
THE OFFSET TRACK POINT
X_WIN_POS = X_WIN_CENTER
Y_WIN_POS = Y_WIN_CENTER
X_WIN_OFF_POS = X_WIN_CENTER
Y_WIN_OFF_POS = Y_WIN_CENTER
RET

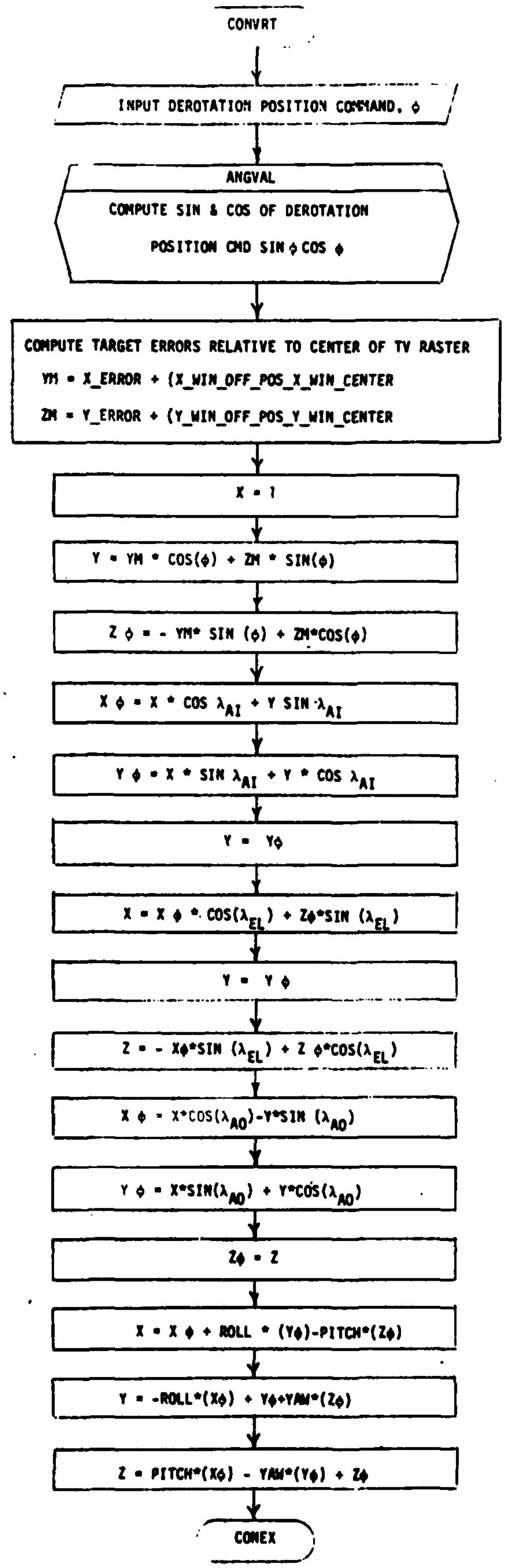

AORAT
COMPUTE SIGMA
SIGMA = 0.7* ABS(SIN λAI) + ABS(COS λE)
λAI = INNER AZIMUTK GIMBAL ANGLE
λE = ELEVATION GIMBAL ANGLE
COMPUTE f(SIGMA)
f(SIGMA) = 0.1 -0.2*SIGMA, SIGMA < 0.5 0, SIGMA ≥0.5
COMPUTE g(SIGMA)
g(SIGMA) = 0.7 / 0.1 - 0.23*SIGMA + 1.5 *(SIGMA)2
COMPUTE OUTER AZ RATE
OUTER-AZ-RATE = g(SIGMA)* f(SIGMA)*(-SIN λAO)+SIGMA*(-SIN λAI)
λAO = OUTER AZIMUTH GIMBAL ANGLE
RET

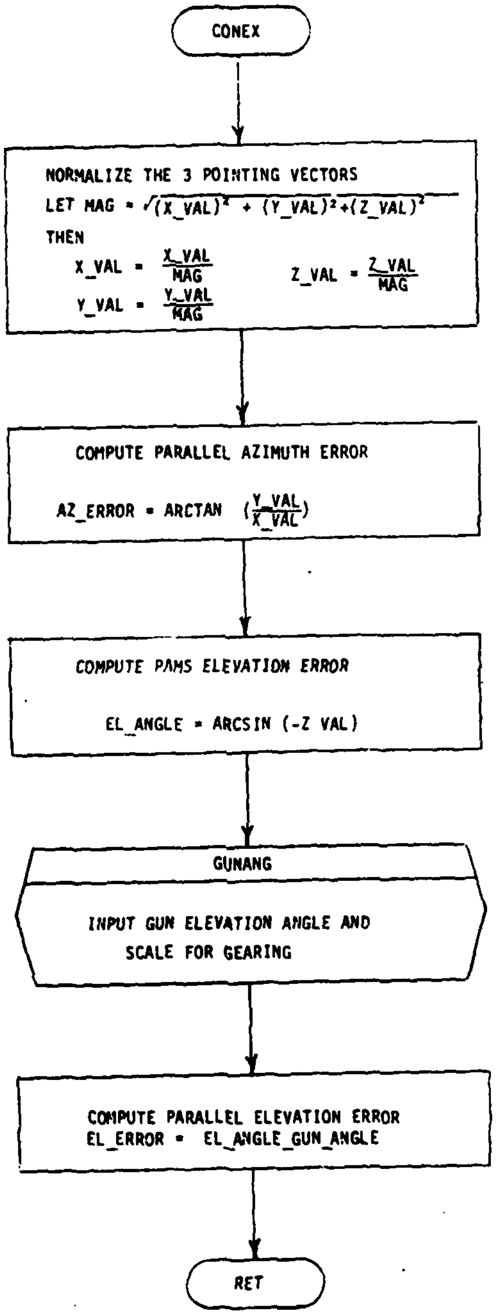

SINE
COMPUTE THE SINE (FRACTION)
USES RELATION SIN(A+B) = SIN(A)+B*COS(A)
(FOR SMALL B)
A IS THE UPPER BYTE OF FRACTION
B IS THE LOWER BYTE OF FRACTION
FINDS SIN(A) AND COS(A) BY DOING
AN 8 BIT TABLE LOOK-UP
RET

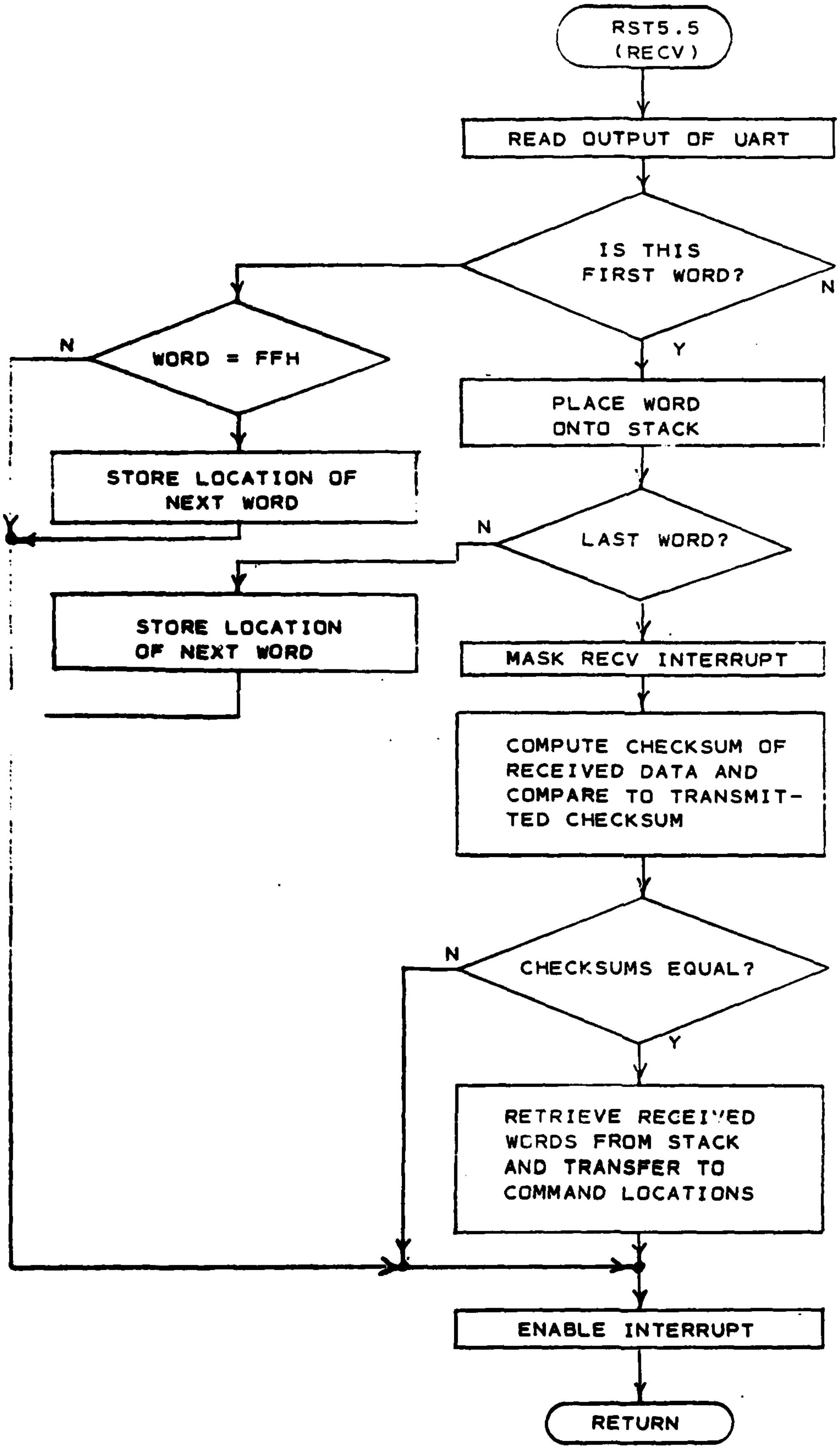

CRIUPD
SAVE OLD GATE SIZE CMD.
GRAY-SLICE-VALID FLAG SET
MANUAL GATE SIZE CMD'D
SET GRAY LEVEL AVG/SLICE CONTROL = AVERAGE
SET GRAY LEVEL AVG/SLICE CONTROL = SLICE
SET CENTROID/CORRELATE CONTROL = CORRELATE
SET CORRELATION ACCUM. CONTROL = 16 BITS
LOAD FOCUS CONTROL CMD. FROM CMD-WD-2 (SENT FROM CONTROL STATION)
RET

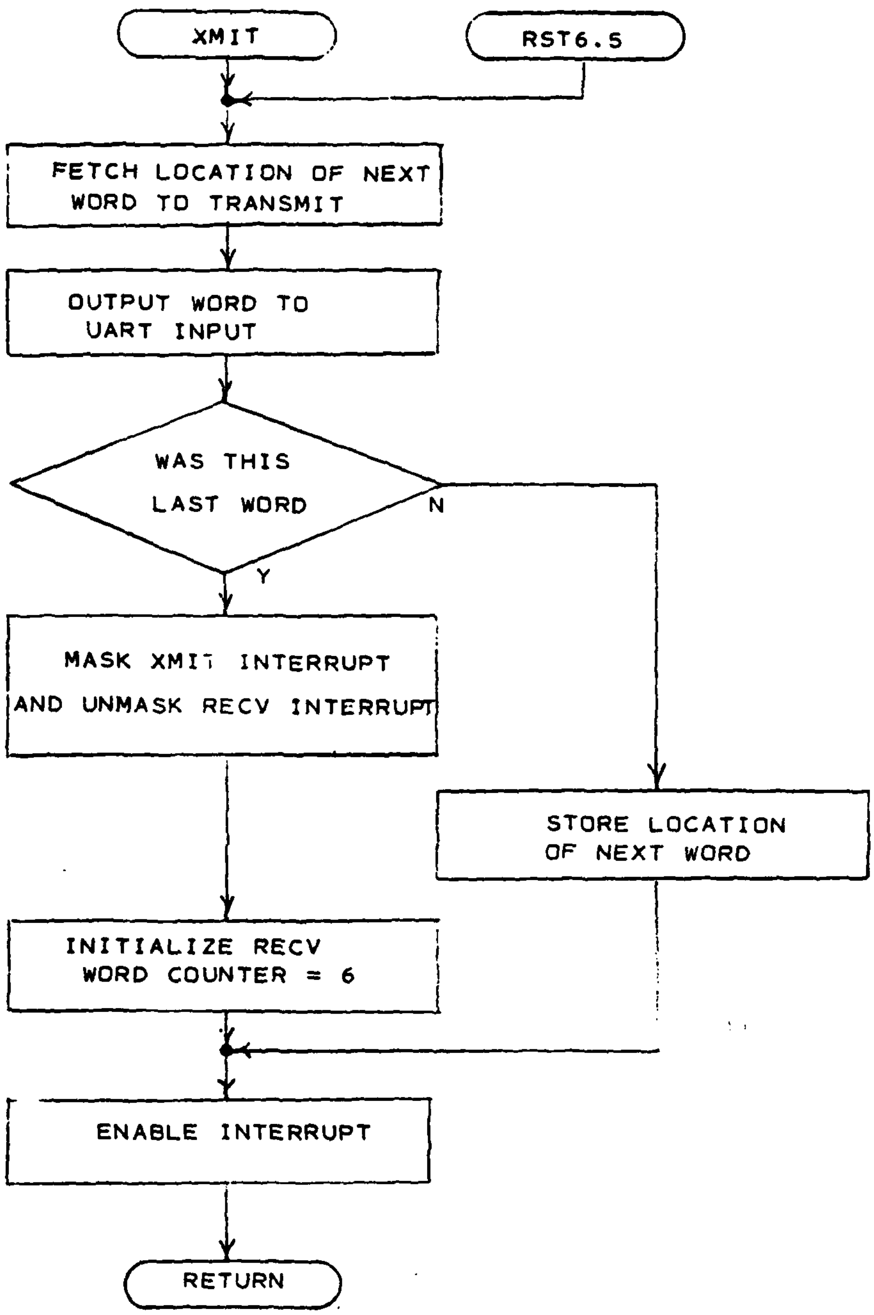

ANGVAL
DETERMINE WHETHER INPUT-ANGLE IS IN QUADRANTS 1&2 OR IN QUADRANTS 3&4
|INPUT-ANGLE| =90°
INPUT-ANGLE IN QUADRANTS 1&2
|INPUT-ANGLE| >90°
SIN = 1 COS = 0
FRACTION = |INPUT-ANGLE|
SIN = -1 COS = 0
COMPUTE -|INPUT-ANGLE|-180= FRACTION
RET
FRACTION = 0
DETERMINE ALONG WHICH AXIS INPUT-ANGLE WAS ORIENTED
SIN = 0 COS = 1
SIN = 1 COS = 0
SIN = 0 COS = -1
SIN = -1 COS = 0
RET
2


2
SINE
COMPUTE
SINE (FRACTION)
(0 ≤ FRACTION ≤ 90°)
INPUT-ANGLE
IN QUADRANTS
1 OR 2
SIN = SIN-FRACTION
SIN = - (SIN-FRACTION)
SUBTRACT FRACTION FROM 90°
FRACTION = 90° - FRACTION
SINE
COMPUTE
SINE (FRACTION)
INPUT-ANGLE
IN QUADRANTS
1 OR 4
COS = SIN-FRACTION
COS = - (SIN-FRACTION)
RET


CONVRT
INPUT DEROTATION POSITION COMMAND, ϕ
ANGVAL
COMPUTE SIN & COS OF DEROTATION
POSITION CMD SIN ϕ COS ϕ
COMPUTE TARGET ERRORS RELATIVE TO CENTER OF TV RASTER
YM = X_ERROR + (X_WIN_OFF_POS_X_WIN_CENTER
ZM = Y_ERROR + (Y_WIN_OFF_POS_Y_WIN_CENTER
X = 1
Y = YM * COS(ϕ) + ZM * SIN(ϕ)
Z ϕ = - YM* SIN (ϕ) + ZM*COS(ϕ)
X ϕ = X * COS λ_{AI} + Y SIN λ_{AI}
Y ϕ = X * SIN λ_{AI} + Y * COS λ_{AI}
Y = Yϕ
X = X ϕ * COS(λ_{EL}) + Zϕ*SIN (λ_{EL})
Y = Y ϕ
Z = - Xϕ*SIN (λ_{EL}) + Z ϕ*COS(λ_{EL})
X ϕ = X*COS(λ_{AO})-Y*SIN (λ_{AO})
Y ϕ = X*SIN(λ_{AO}) + Y*COS(λ_{AO})
Zϕ = Z
X = X ϕ + ROLL * (Yϕ)-PITCH*(Zϕ)
Y = -ROLL*(Xϕ) + Yϕ+YAW*(Zϕ)
Z = PITCH*(Xϕ) - YAW*(Yϕ) + Zϕ
CONEX


CONEX
NORMALIZE THE 3 POINTING VECTORS
LET MAG = √((X_VAL)² + (Y_VAL)² + (Z_VAL)²)
THEN
X_VAL = X_VAL / MAG
Y_VAL = Y_VAL / MAG
Z_VAL = Z_VAL / MAG
COMPUTE PARALLEL AZIMUTH ERROR
AZ_ERROR = ARCTAN (Y_VAL / X_VAL)
COMPUTE PAMS ELEVATION ERROR
EL_ANGLE = ARCSIN (-Z VAL)
GUNANG
INPUT GUN ELEVATION ANGLE AND
SCALE FOR GEARING
COMPUTE PARALLEL ELEVATION ERROR
EL_ERROR = EL_ANGLE_GUN_ANGLE
RET


RST5.5
(RECV)
READ OUTPUT OF UART
IS THIS
FIRST WORD?
N
Y
N
WORD = FFH
PLACE WORD
ONTO STACK
STORE LOCATION OF
NEXT WORD
N
LAST WORD?
STORE LOCATION
OF NEXT WORD
MASK RECV INTERRUPT
COMPUTE CHECKSUM OF
RECEIVED DATA AND
COMPARE TO TRANSMIT-
TED CHECKSUM
N
CHECKSUMS EQUAL?
Y
RETRIEVE RECEIVED
WORDS FROM STACK
AND TRANSFER TO
COMMAND LOCATIONS
ENABLE INTERRUPT
RETURN


XMIT
RST6.5
FETCH LOCATION OF NEXT WORD TO TRANSMIT
OUTPUT WORD TO UART INPUT
WAS THIS LAST WORD
N
Y
MASK XMIT INTERRUPT AND UNMASK RECV INTERRUPT
STORE LOCATION OF NEXT WORD
INITIALIZE RECV WORD COUNTER = 6
ENABLE INTERRUPT
RETURN

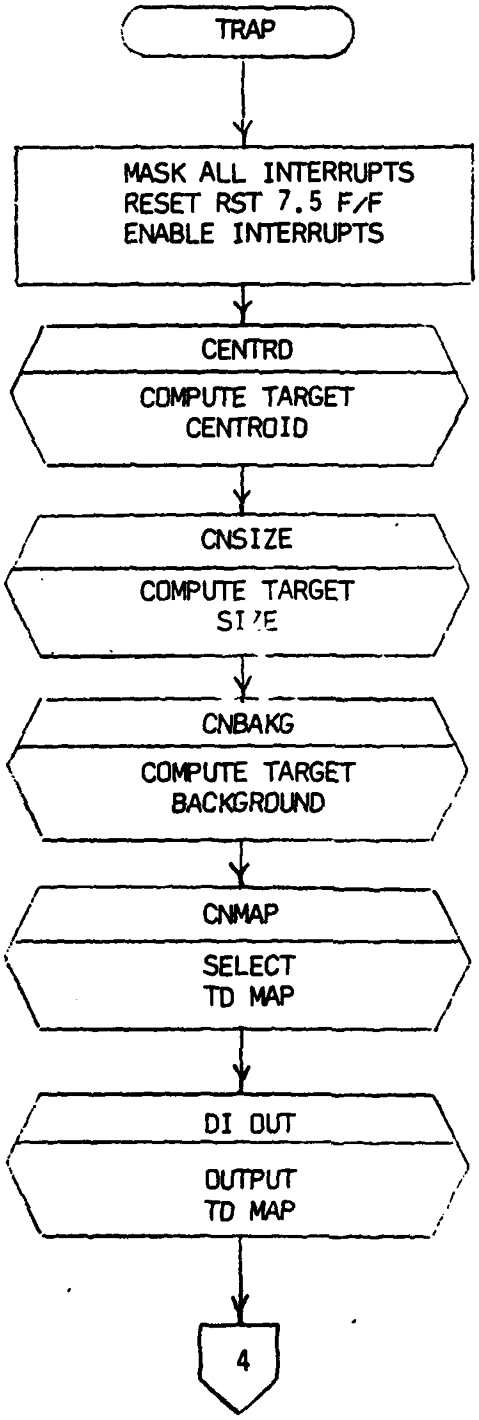
COLD-START FLAG	FLGCLD	Set if cold start has not been completed
AUTO-TRACK FLAG	FLGAUT	Set if auto track is commanded
GATE-SIZE-CHANGE FLAG	FLGEAT	Set if gate size has changed
WINDOW-MOU-LIMIT	FLEWIN	Set if window movement would exceed preset limits
FOV-CHANGE FLAG	FLGSW	Set if FOV has changed in past 15 frames
ACQUISITION FLAG	FLGACQ	Set if target has been acquired
BORESIGHT-LOCKED-UP FLAG	FLGBOR	Set if auto boresight loop is locked up (valid only when auto boresight is commanded.
COAST FLAG	FLGCST	Set if coast
TARGET-COAST FLAG	TGTCST	Set if coast was caused by cross correlation min exceeding the coast threshold
EXIT-COAST FLAG	COEXIT	Set if coast has just been exited
EXIT-OFFSET-TRK FLAG	OTEXIT	Set if offset track has just been exited
OFFSET-TRK FLAG	FLGOFF	Set if offset track is commanded
RE-ACQUIRE FLAG		
REF-TRACKABLE FLAG	FLGREF	Set if reference is trackable
REF-INDICATOR FLAG	FLGRFI	Set if reference selected is "right" ref.
GRAY-SLICE-VALID FLAG	SLCVAL	
MAP-CHANGE FLAG	MAPCHG	
AZ-LIMIT-EXCEEDED FLAG	B6/FLAGS+1	Set if measured az error has exceeded the limit switch setting
EL-LIMIT-EXCEEDED FLAG	B7/FLAGS+1	" " " el " " " " " " "
FLAGS-WORD-1	FLAGS	Tracker status flags, sent to control station
FLAGS-WORD-2	FLAGS+1	" " " " " " "

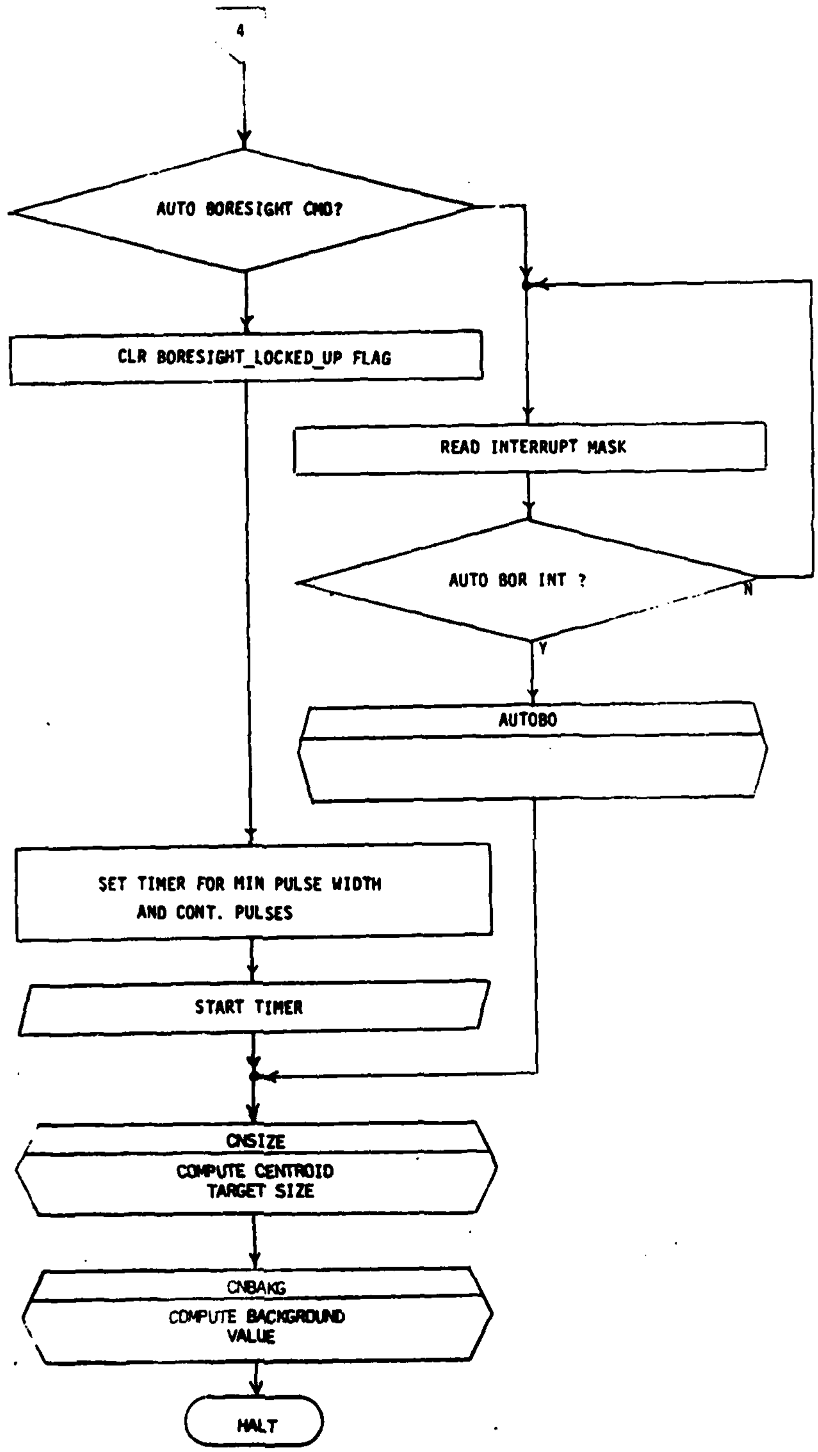
UPDATE-DELAY	TIMUPD	Counts number of consecutive update request	
COAST-TIMEOUT	TIMCST	Coast timeout counter	
FOV-CHG-TIMEOUT	TIMFOV	FOV change timeout counter	
UPDATE-THRESHOLD	UPDAT	Update threshold	
COAST-THRESHOLD	COAST	Coast threshold	
NEW-UPDATE-THRESHOLD	NEWUPD	New update threshold	computed as a function
NEW-COAST-THRESHOLD	NEWCST	New coast threshold	of autocorrelation results
TRACK-THRESHOLD	SLPTHR	Autocorrelation slope threshold for trackability assessment	
CROSS-CORR-MIN	CORRV	Minimum of the cross correlation function	
GATE-SIZE	GATSZ	Gate size index	
FOV	FOV	Field of view index	
CMD-REG-1	CMDR1	Hardware control register #1	
CMD-REG-2	CMDR2	" " " #2	
CMD-WD-1	CMDWD1	Mode, gate size & autoboresight	
CMD-WD-2	CMDWD2	Field fo view, mode & focus command	command words
X-STICK	XSTICK	X value of hand control input	from control
Y-STICK	XSTICK	Y value of hand control input	station
X-WIN-CENTER	XWINϕ	Center position for window, horizontal	
Y-WIN-CENTER	YWINϕ	Center position for window, vertical	
X-WIN-POS	XWIN	Horizontal window position	
Y-WIN-POS	YWIN	Vertical window position	
X-WIN-OFF-POS	XWINϕϕ	Horizontal offset track point	
Y-WIN-OFF-POS	YWINϕϕ	Vertical offset track point	

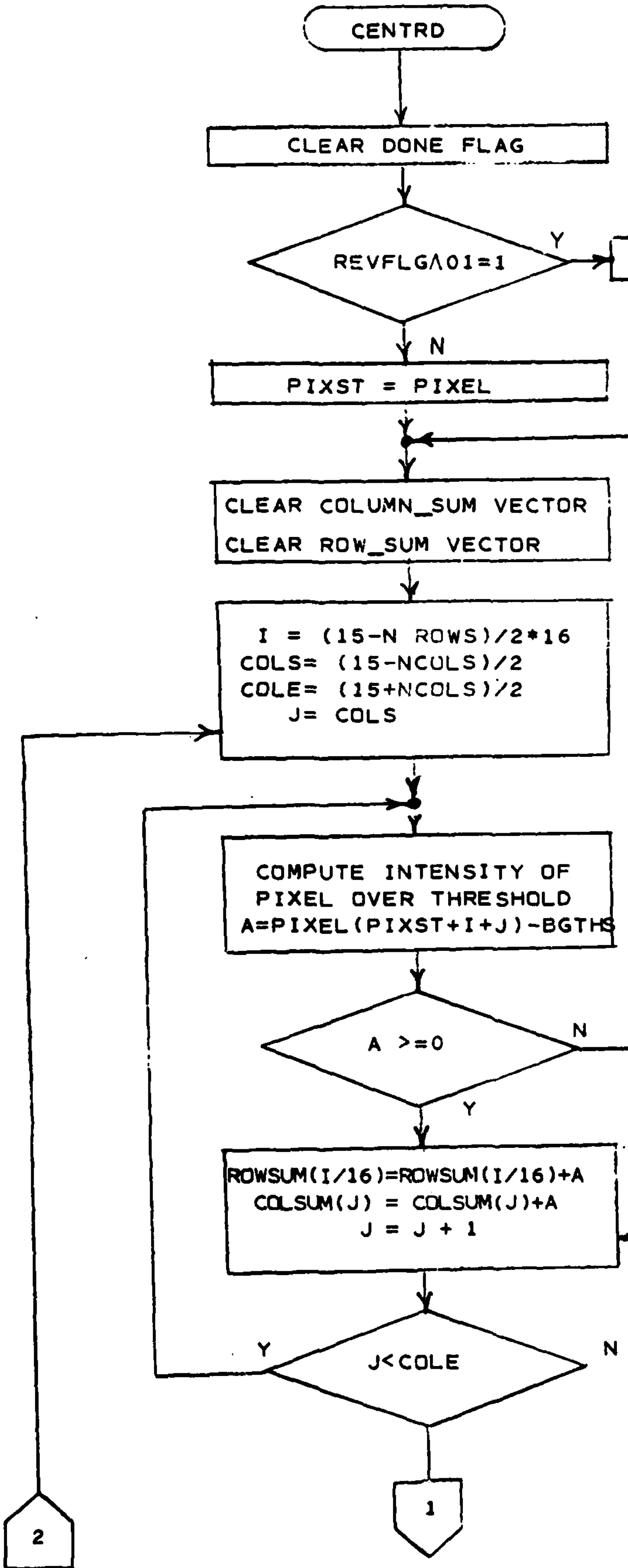
OUT-AZ-RATE	AORATL	OUTER AZIMUTH RATE COMMAND	
INNER-AZ-RATE	XRATEL	INNER AZIMUTH RATE COMMAND	
EL-RATE	YRATEL	ELEVATION RATE COMMAND	
DEROTATION-POS	DRPOSL	DEROTATION POSITION COMMAND	
X-ERROR-SP	XERR1	DETECTED HORIZONTAL ERROR IN TARGET POSITION RELATIVE TO WINDOW POSITION	In Super Pixels
Y-ERROR-SP	YERR1	DETECTED VERITCAL ERROR IN TARGET POSITION RELATIVE TO WINDOW POSITION	
X-DELTA	DELTAX	Interpolator correction, horizontal	In rastes element
Y-DELTA	DELTAY	Interpolator correction, vertical	
X-ERROR	XERR	Interpolated horizontal error relative to window position	In raster element
Y-ERROR	YERR	Interpolated vertical error relative to window position	
XX-ERROR	XACCN	Interpolated horizontal error relative to offset track window position	In raster element
YY-ERROR	YACCN	Interpolated vertical error relative to offset track window position	
PRM-FRM-WIN-LIMIT	LIMS	Frame to frame window movement limit	
X-LIM-LOW	XLIMS	Lower limit of horizontal window position	
X-LIM-HIGH	XLIMS+1	Upper " " " " "	Gate size dependent
Y-LIM-LOW	YLIMS	Lower " " vertical " "	
Y-LIM-HIGH	YLIMS+1	Upper " " " " "	
X-ACCUM	MXACCN	Filter equation X accumulator for manual track	
Y-ACCUM	MXACCN	" " Y " " " "	
OFF-X-ACCUM	OFFX	Offset track horizontal stick accumulator	
OFF-Y=ACCUM	OFFY	" " vertical " "	

AZ-ERROR	AZERR	Parallel azimuth gun pointing error
EL-ERROR	ELERR	" elevation " " "
GUN-ANGLE		Gun elevation angle, sealed for gun resolver gearing
INPUT-ANGLE	-	Input angle to the ANGOAL routine
SIN	SINTX	The sine of the angle inputted to the ANGVAL routine
COS	COSTX	" cosine of the angle inputted to the ANGVAL routine
FRACTION	FRACT	0 to 90 deg. input to SINE routine
SINE-FRACTION	-	The sine of the 0 to 90^{o} angle inputted to the SINE routine

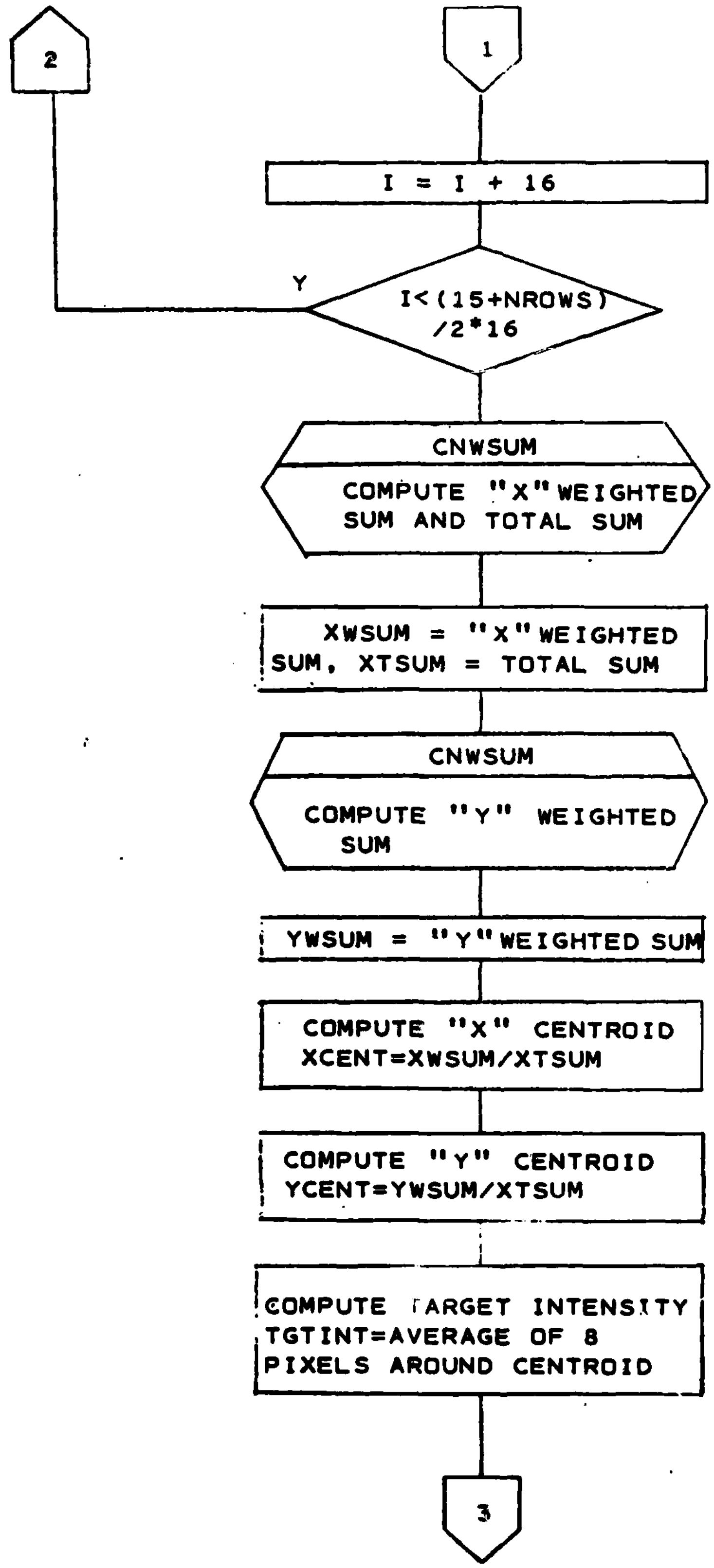
APPENDIX C - SIGNAL PROCESSOR SOFTWARE DIAGRAMS

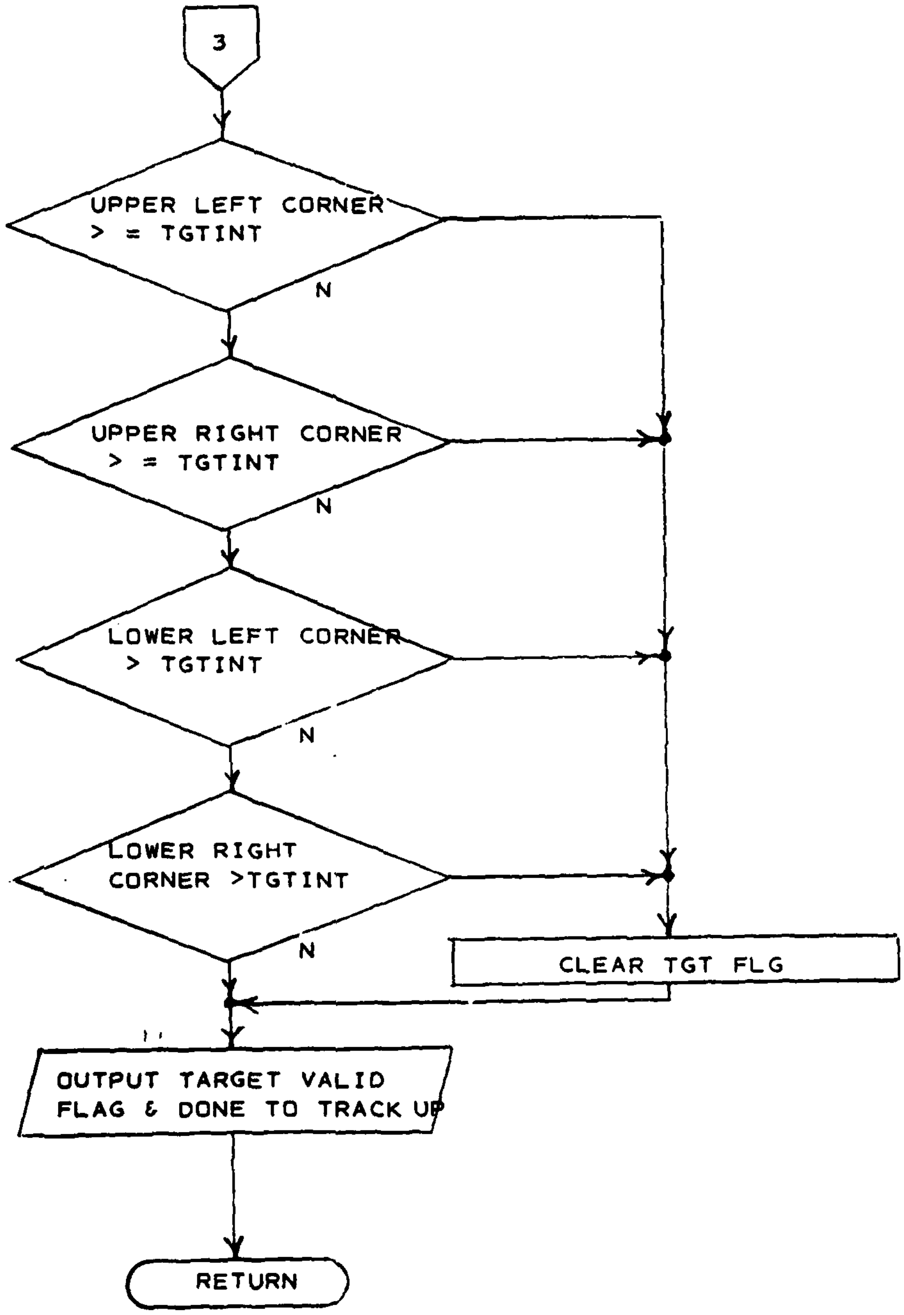


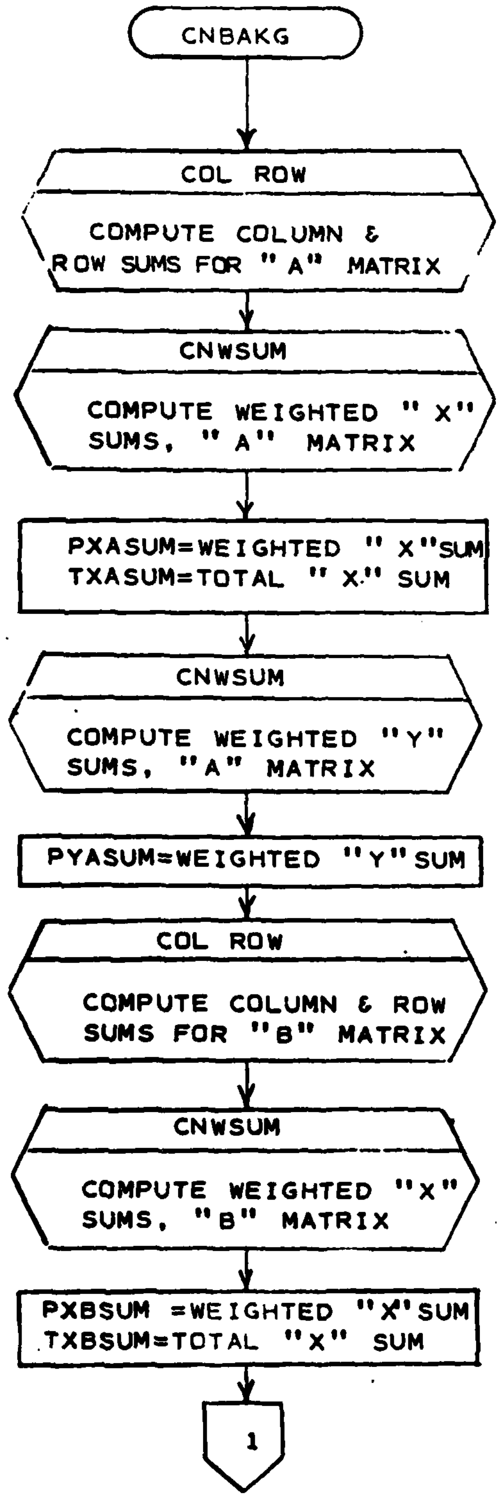

4
AUTO BORESIGHT CMD?
CLR BORESIGHT_LOCKED_UP FLAG
READ INTERRUPT MASK
AUTO BOR INT ?
N
Y
AUTOBO
SET TIMER FOR MIN PULSE WIDTH
AND CONT. PULSES
START TIMER
CNSIZE
COMPUTE CENTROID
TARGET SIZE
CNBAKG
COMPUTE BACKGROUND
VALUE
HALT

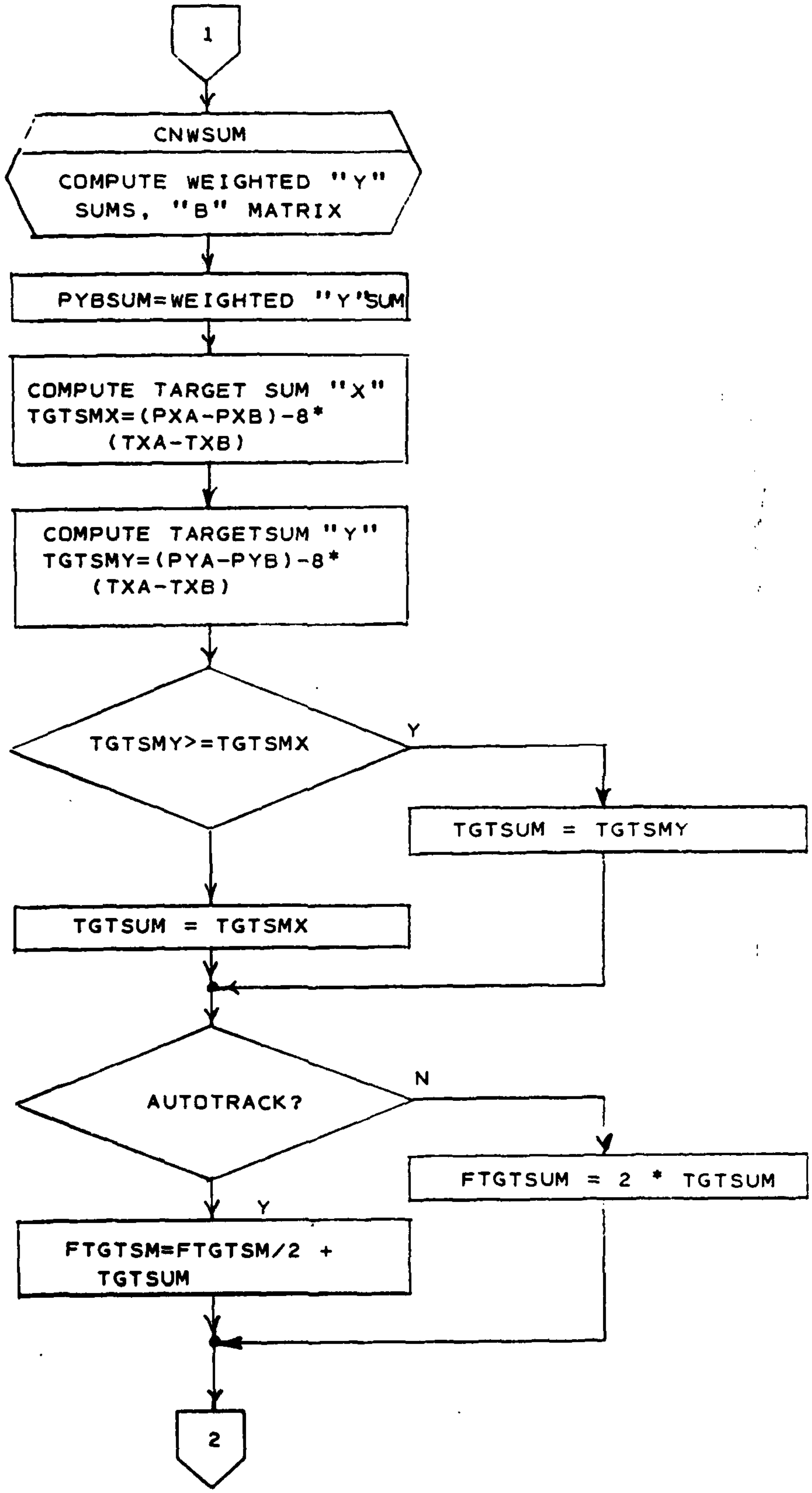


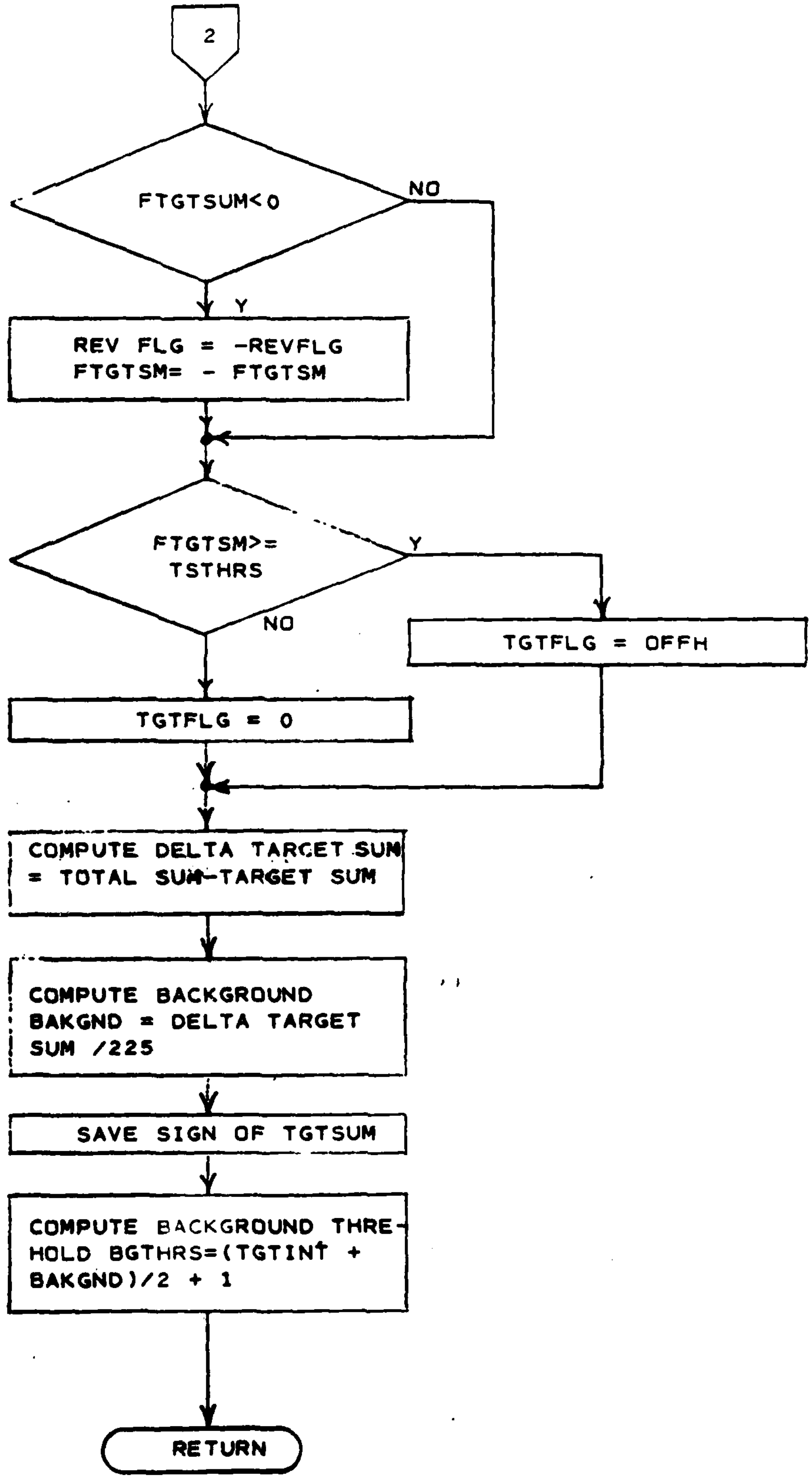
NOTE: THIS SECTION OF THE FLOW CHART SHOWS LOGIC ONLY. DUE TO SPEED CONSIDERATIONS, IT IS WRITTEN AS IN LINE CODE. VARIABLES I AND J ARE DUMMYS AND THE LOOPS DO NOT REALLY EXIST.

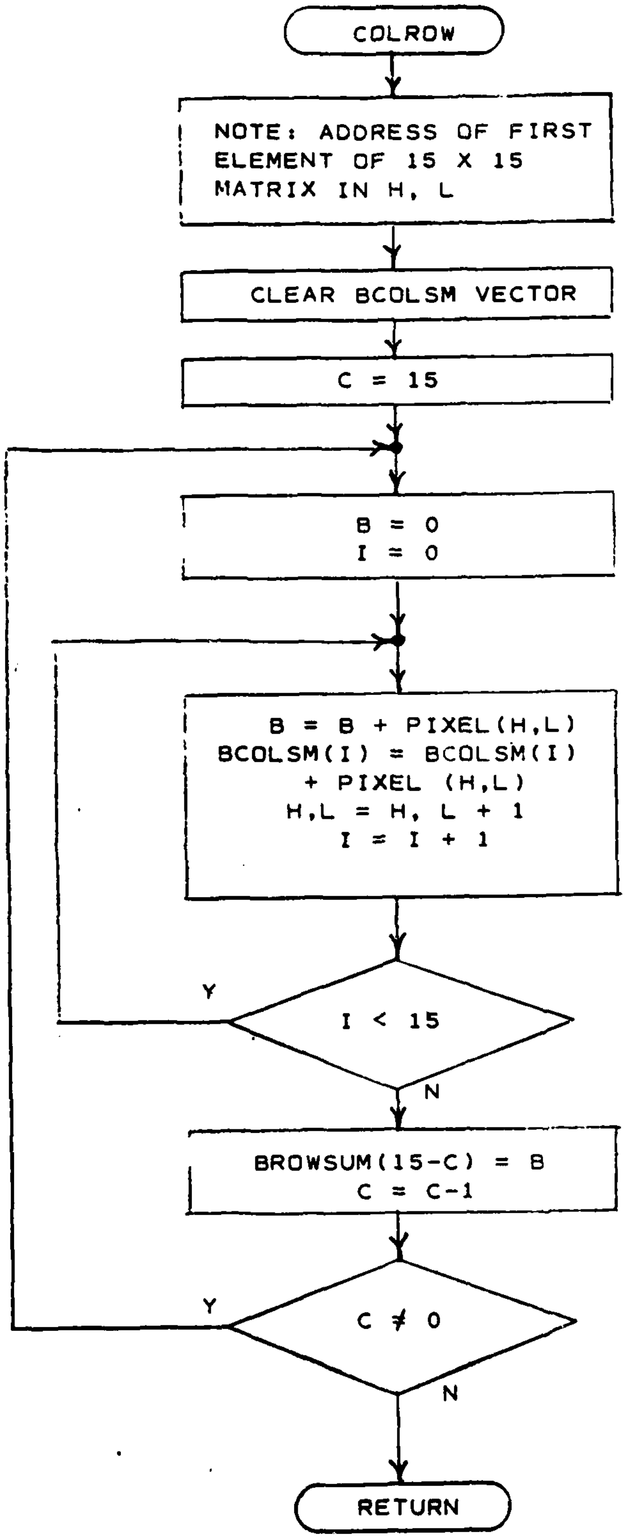

2
1
I = I + 16
Y
I<(15+NROWS)
/2*16
CNWSUM
COMPUTE "X" WEIGHTED
SUM AND TOTAL SUM
XWSUM = "X" WEIGHTED
SUM, XTSUM = TOTAL SUM
CNWSUM
COMPUTE "Y" WEIGHTED
SUM
YWSUM = "Y" WEIGHTED SUM
COMPUTE "X" CENTROID
XCENT=XWSUM/XTSUM
COMPUTE "Y" CENTROID
YCENT=YWSUM/XTSUM
COMPUTE TARGET INTENSITY
TGTINT=AVERAGE OF 8
PIXELS AROUND CENTROID
3


3
UPPER LEFT CORNER
> = TGTINT
N
UPPER RIGHT CORNER
> = TGTINT
N
LOWER LEFT CORNER
> TGTINT
N
LOWER RIGHT
CORNER >TGTINT
N
CLEAR TGT FLG
OUTPUT TARGET VALID
FLAG & DONE TO TRACK UP
RETURN

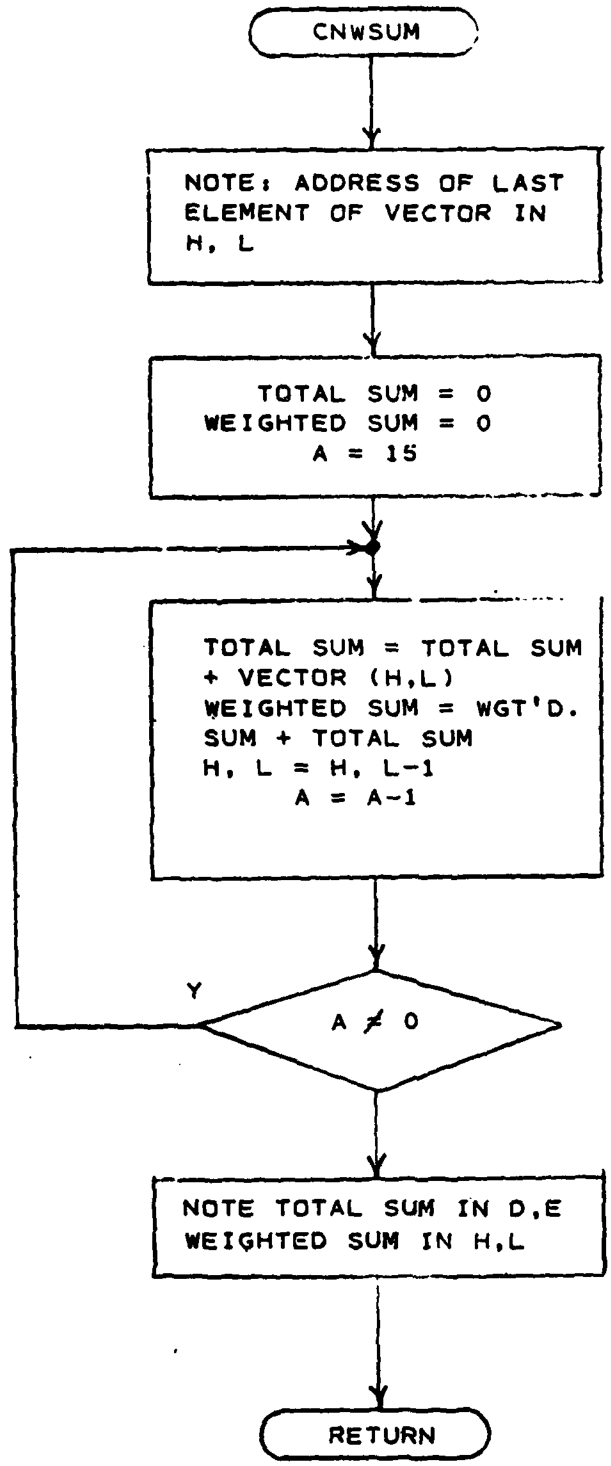

CNBAKG
COL ROW
COMPUTE COLUMN & ROW SUMS FOR "A" MATRIX
CNWSUM
COMPUTE WEIGHTED "X" SUMS, "A" MATRIX
PXASUM=WEIGHTED "X" SUM
TXASUM=TOTAL "X" SUM
CNWSUM
COMPUTE WEIGHTED "Y" SUMS, "A" MATRIX
PYASUM=WEIGHTED "Y" SUM
COL ROW
COMPUTE COLUMN & ROW SUMS FOR "B" MATRIX
CNWSUM
COMPUTE WEIGHTED "X" SUMS, "B" MATRIX
PXBSUM =WEIGHTED "X" SUM
TXBSUM=TOTAL "X" SUM
1

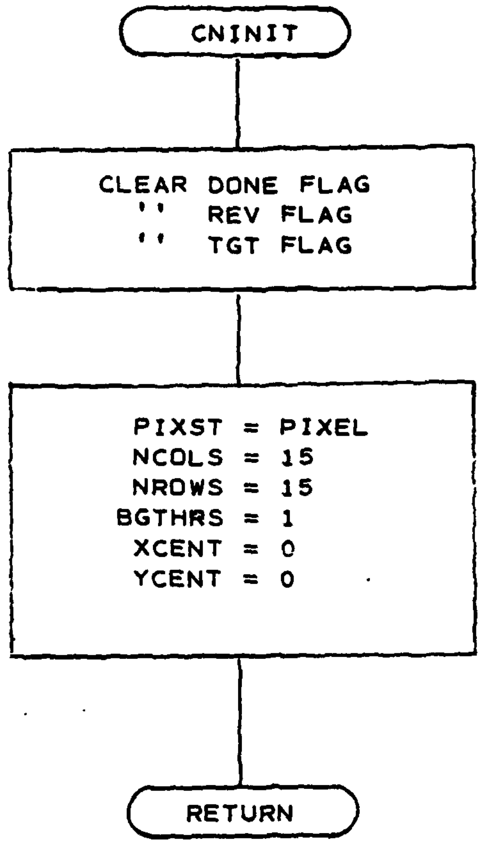

1
CNWSUM
COMPUTE WEIGHTED "Y" SUMS, "B" MATRIX
PYBSUM=WEIGHTED "Y"SUM
COMPUTE TARGET SUM "X" TGTSMX=(PXA-PXB)-8* (TXA-TXB)
COMPUTE TARGETSUM "Y" TGTSMY=(PYA-PYB)-8* (TXA-TXB)
TGTSMY>=TGTSMX
Y
TGTSUM = TGTSMY
TGTSUM = TGTSMX
AUTOTRACK?
N
FTGTSUM = 2 * TGTSUM
Y
FTGTSM=FTGTSM/2 + TGTSUM
2

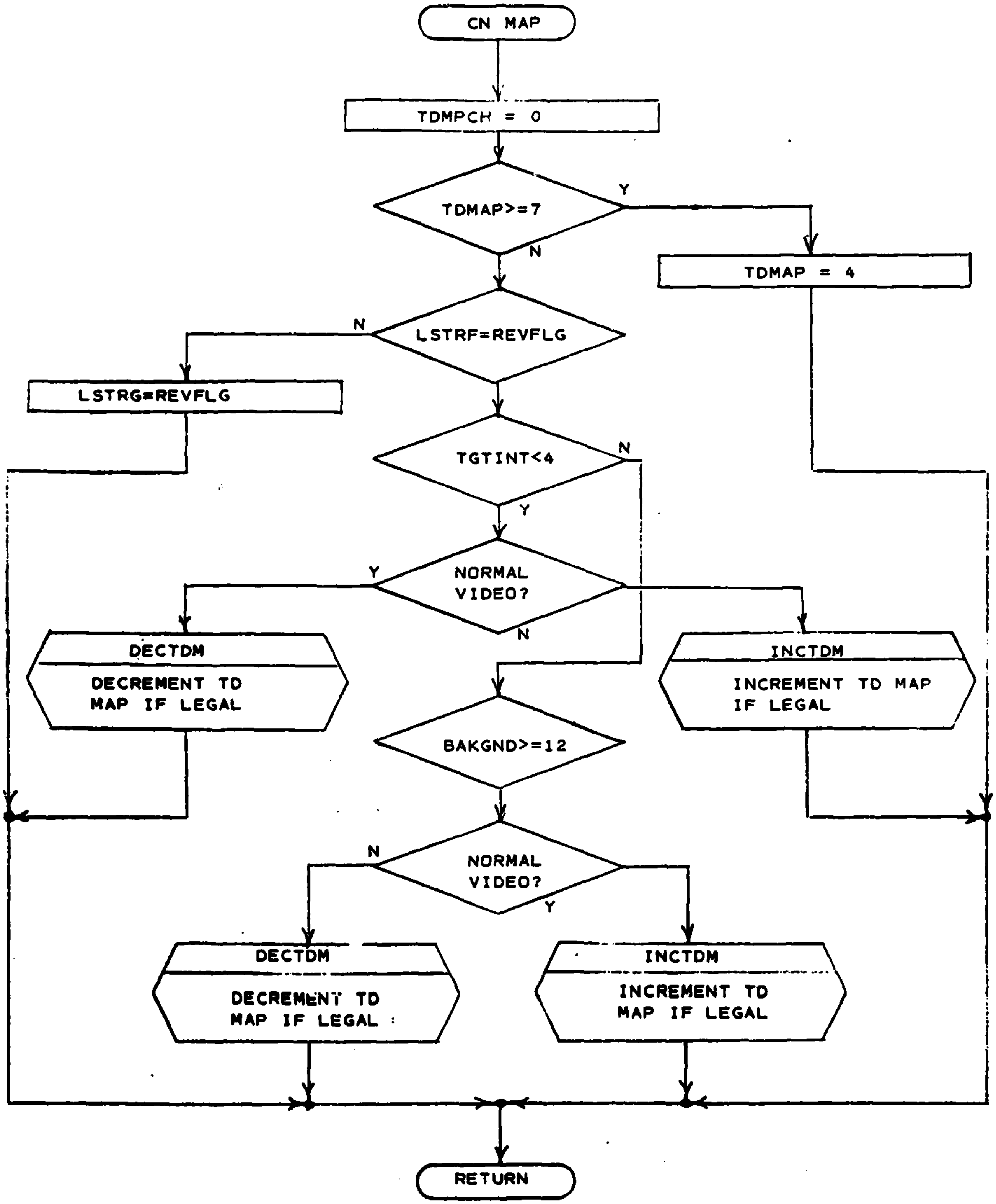

2
FTGTSUM<0
NO
Y
REV FLG = -REVFLG
FTGTSM= - FTGTSM
FTGTSM>=
TSTHRS
Y
NO
TGTFLG = OFFH
TGTFLG = 0
COMPUTE DELTA TARGET SUM
= TOTAL SUM-TARGET SUM
COMPUTE BACKGROUND
BAKGND = DELTA TARGET
SUM /225
SAVE SIGN OF TGTSUM
COMPUTE BACKGROUND THRE-
HOLD BGTHRS=(TGTINT +
BAKGND)/2 + 1
RETURN

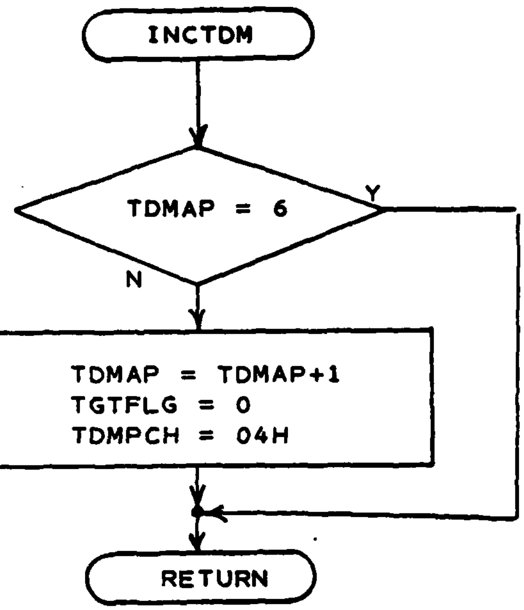


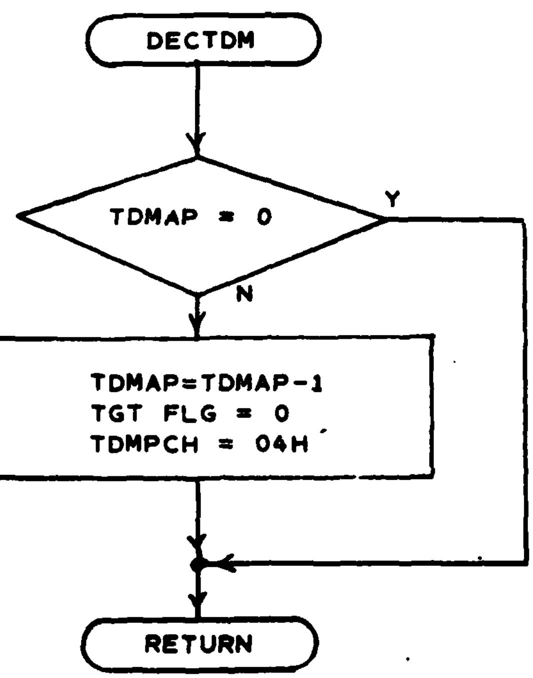
NOTE: THIS PORTION OF THE FLOW CHART SHOWS LOGIC FLOW ONLY. DUE TO SPEED CONSIDERATIONS IT IS WRITTEN AS IN LINE CODE. I IS A DUMMY VARIABLE AND THE INNER D LOOP DOES NOT REALLY EXIST.

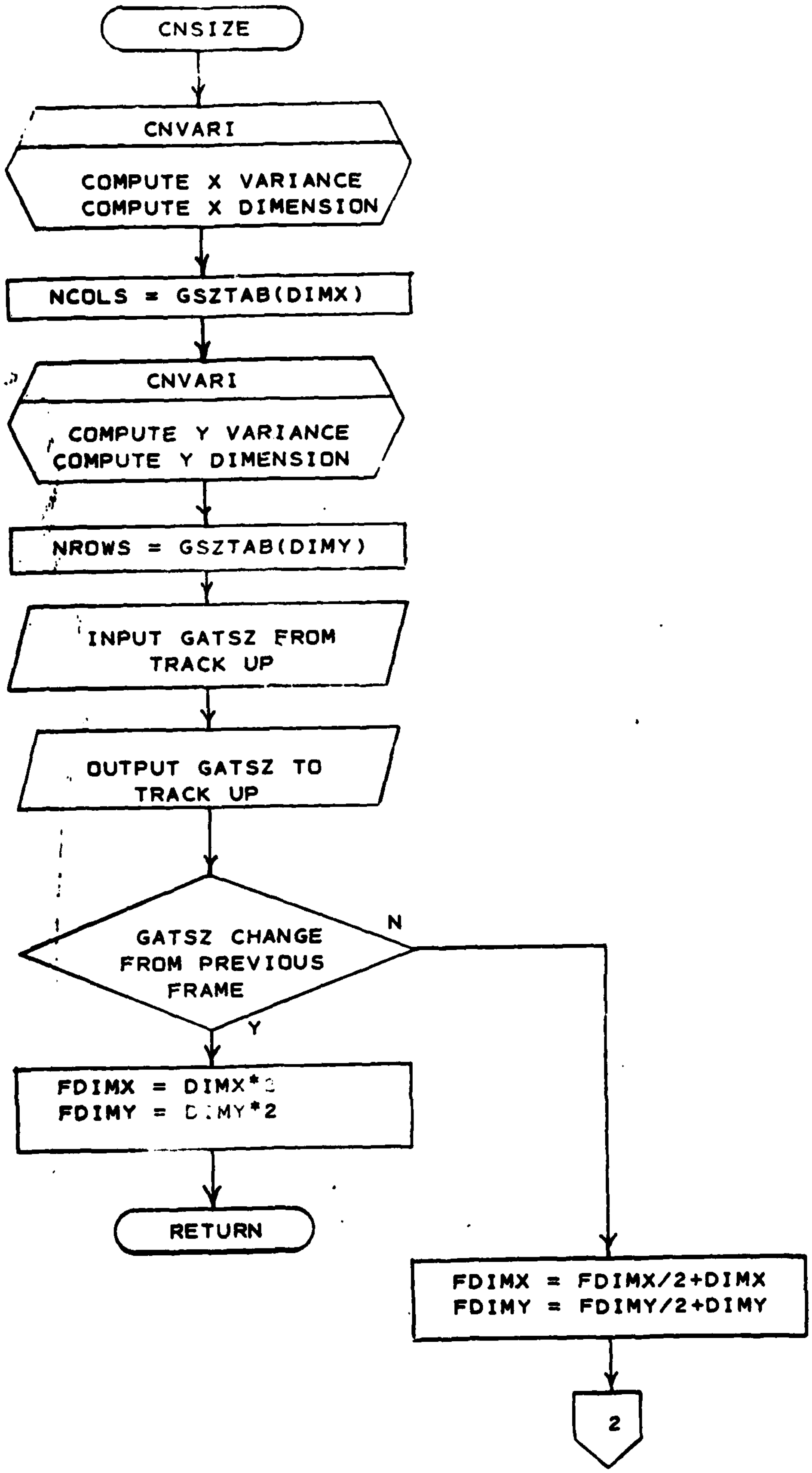

CNWSUM
NOTE: ADDRESS OF LAST ELEMENT OF VECTOR IN H, L
TOTAL SUM = 0
WEIGHTED SUM = 0
A = 15
TOTAL SUM = TOTAL SUM + VECTOR (H,L)
WEIGHTED SUM = WGT'D. SUM + TOTAL SUM
H, L = H, L-1
A = A-1
Y
A ≠ 0
NOTE TOTAL SUM IN D,E
WEIGHTED SUM IN H,L
RETURN

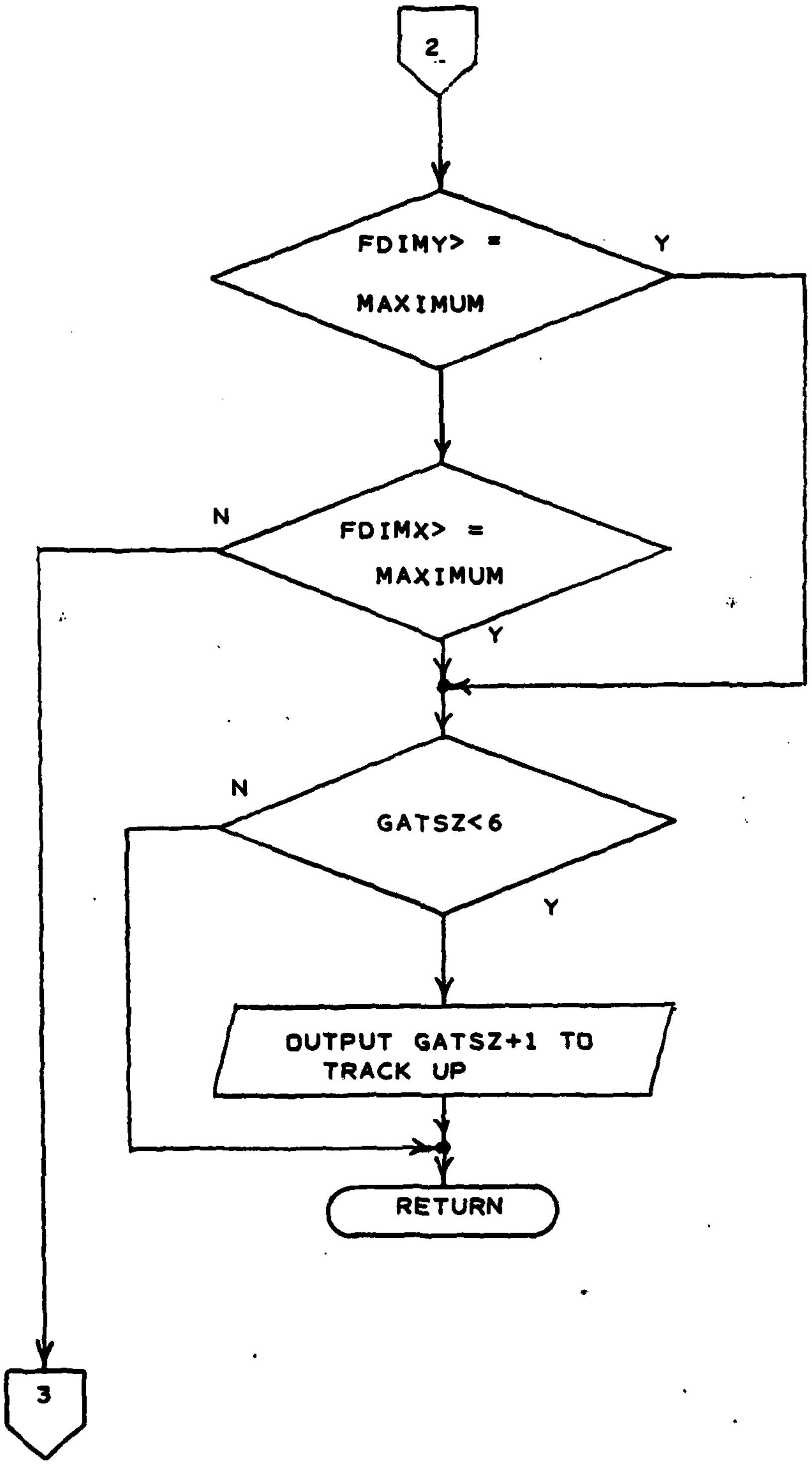

CNINIT
CLEAR DONE FLAG
" REV FLAG
" TGT FLAG
PIXST = PIXEL
NCOLS = 15
NROWS = 15
BGTHRS = 1
XCENT = 0
YCENT = 0
RETURN

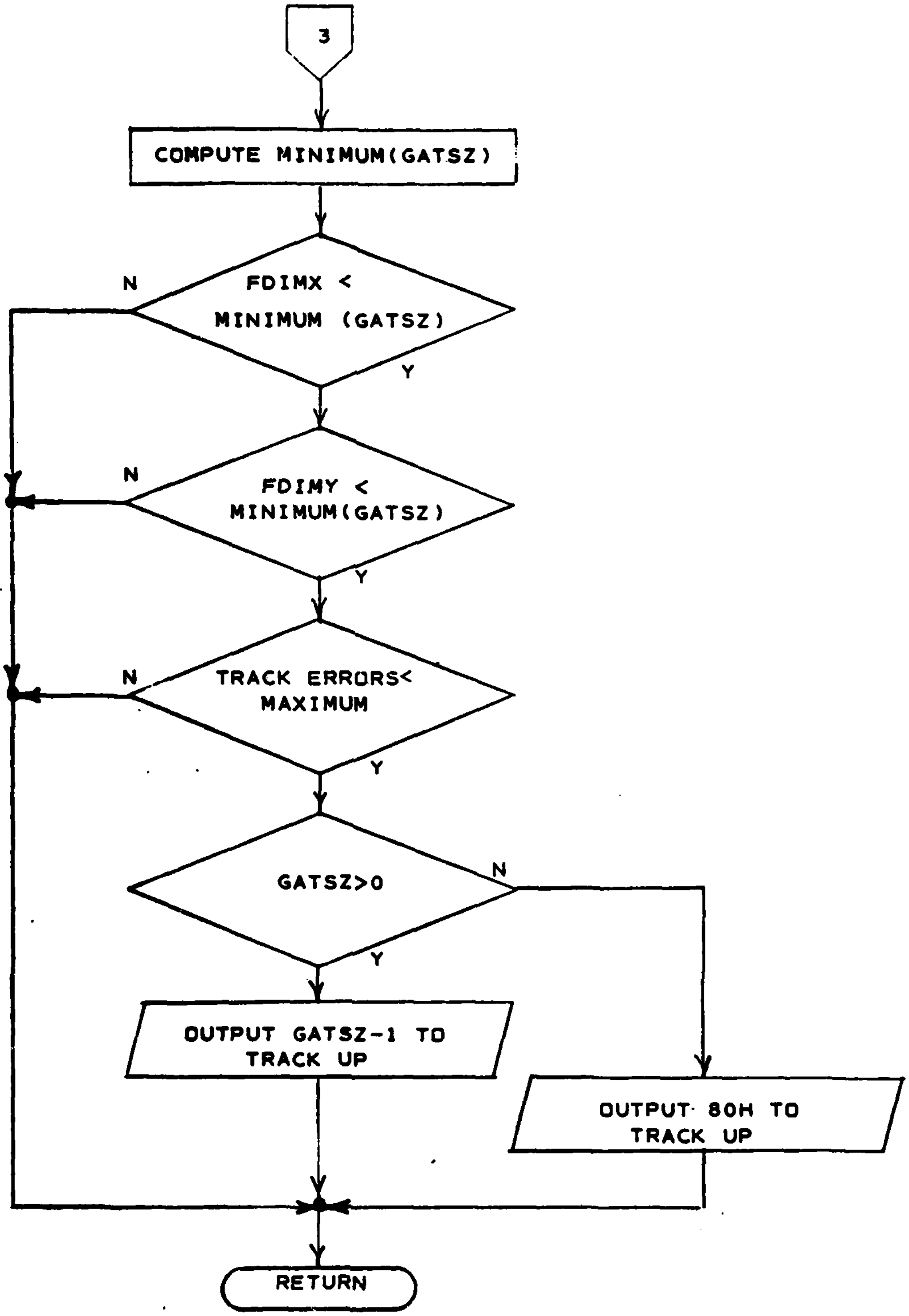

CN MAP
TDMPCH = 0
TDMAP>=7
Y
N
TDMAP = 4
LSTRF=REVFLG
N
LSTRG=REVFLG
TGTINT<4
N
Y
NORMAL VIDEO?
Y
N
DECTDM
DECREMENT TD MAP IF LEGAL
INCTDM
INCREMENT TD MAP IF LEGAL
BAKGND>=12
NORMAL VIDEO?
N
Y
DECTDM
DECREMENT TD MAP IF LEGAL
INCTDM
INCREMENT TD MAP IF LEGAL
RETURN

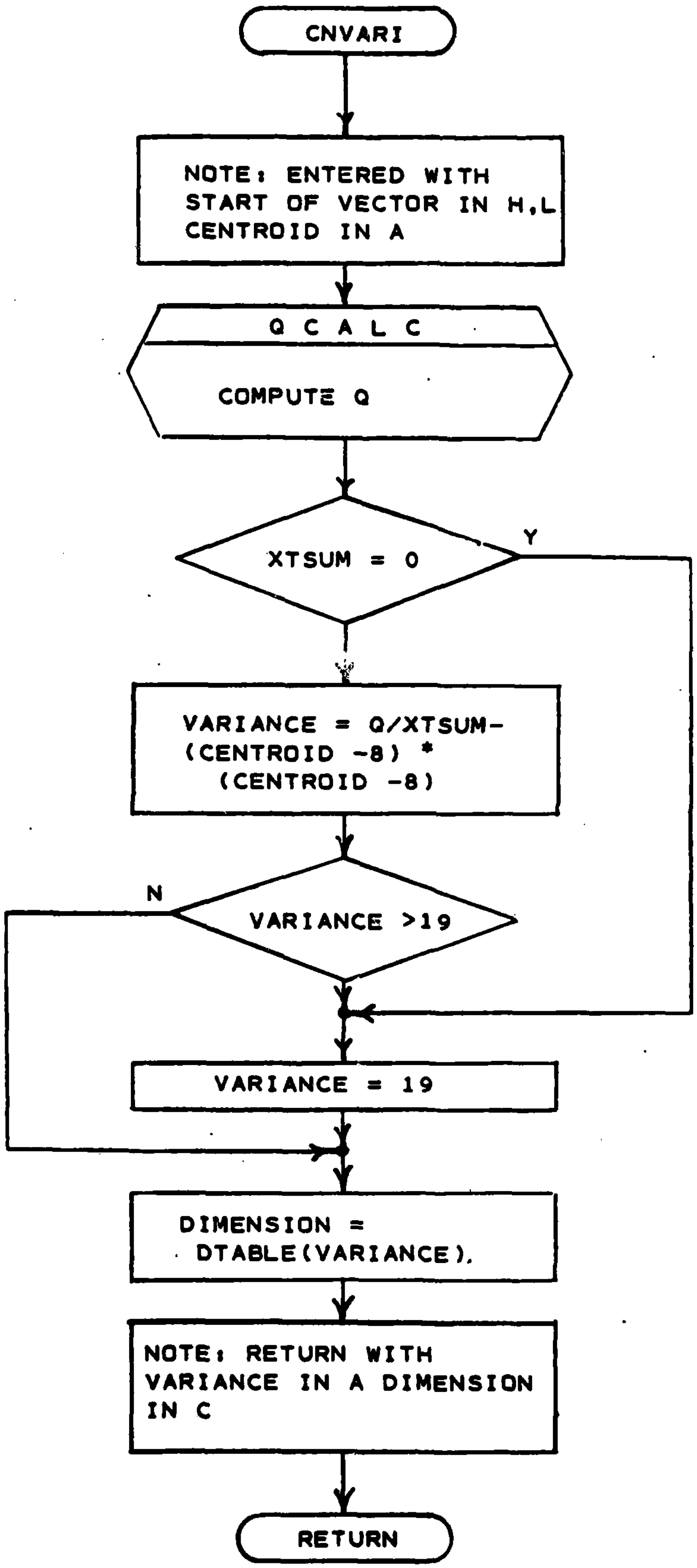

INCTDM
TDMAP = 6
Y
N
TDMAP = TDMAP+1
TGTFLG = 0
TDMPCH = 04H
RETURN

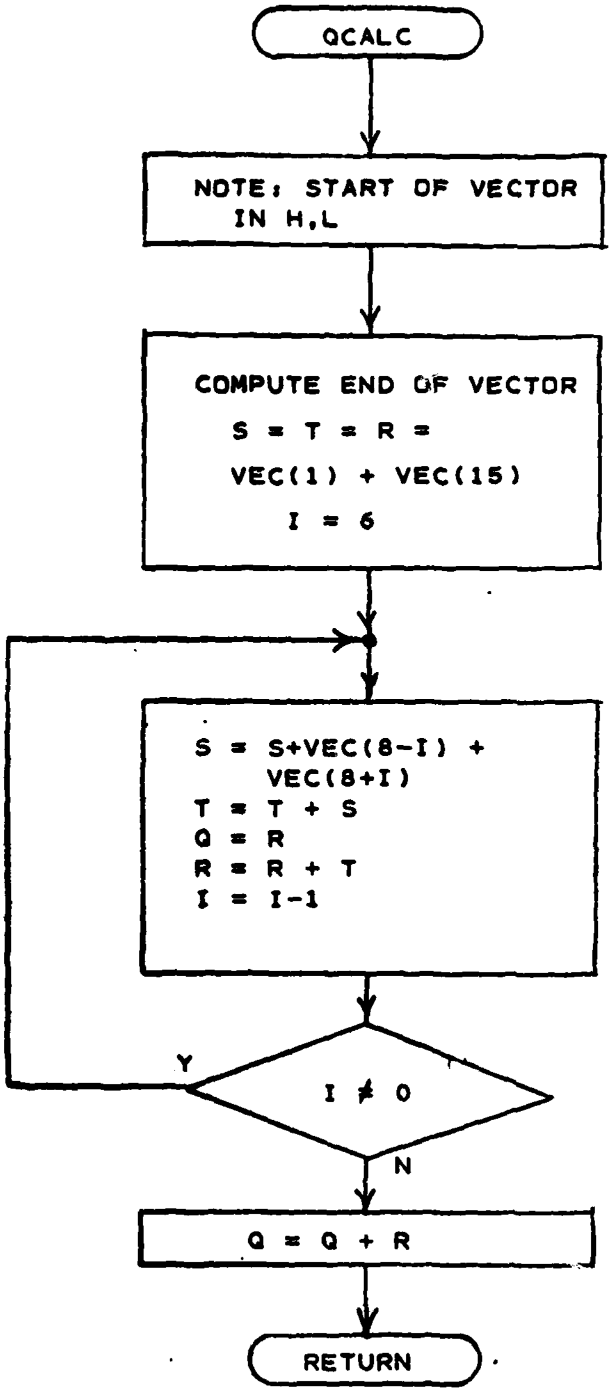

DECTDM
TDMAP = 0
Y
N
TDMAP=TDMAP-1
TGT FLG = 0
TDMPCH = 04H
RETURN

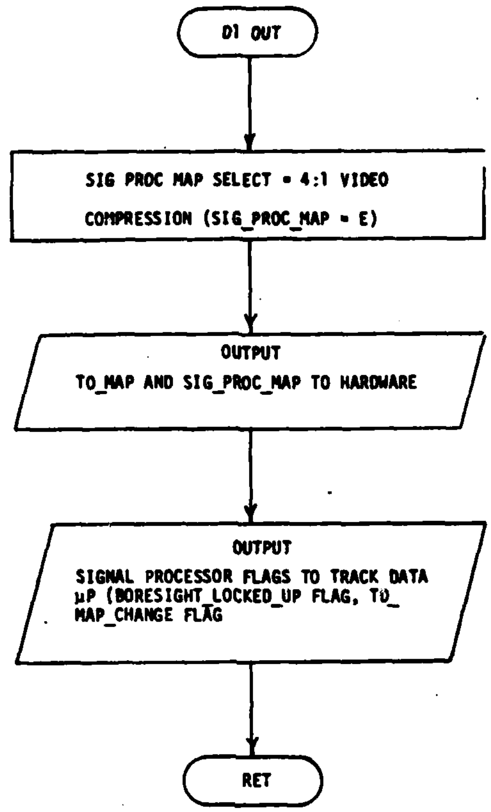

CNSIZE
CNVARI
COMPUTE X VARIANCE
COMPUTE X DIMENSION
NCOLS = GSZTAB(DIMX)
CNVARI
COMPUTE Y VARIANCE
COMPUTE Y DIMENSION
NROWS = GSZTAB(DIMY)
INPUT GATSZ FROM
TRACK UP
OUTPUT GATSZ TO
TRACK UP
GATSZ CHANGE
FROM PREVIOUS
FRAME
N
Y
FDIMX = DIMX*
FDIMY = DIMY*2
RETURN
FDIMX = FDIMX/2+DIMX
FDIMY = FDIMY/2+DIMY
2

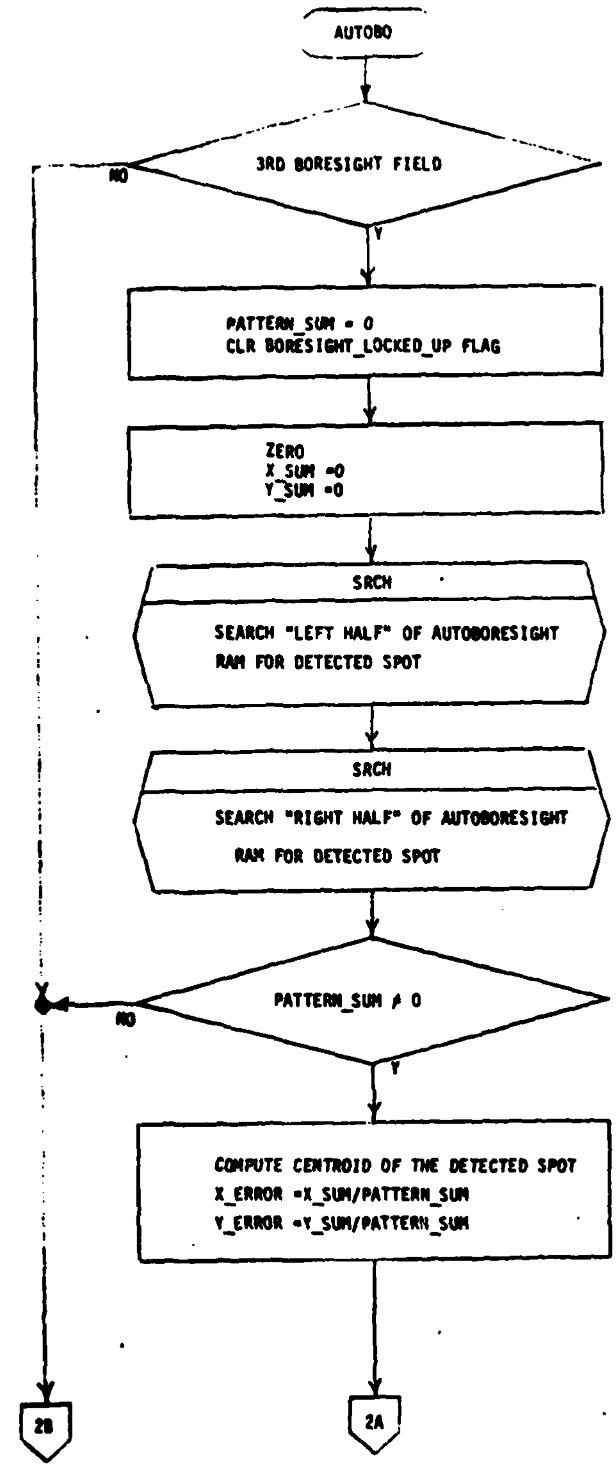

2
FDIMY> =
MAXIMUM
Y
N
FDIMX> =
MAXIMUM
Y
N
GATSZ<6
Y
OUTPUT GATSZ+1 TO
TRACK UP
RETURN
3

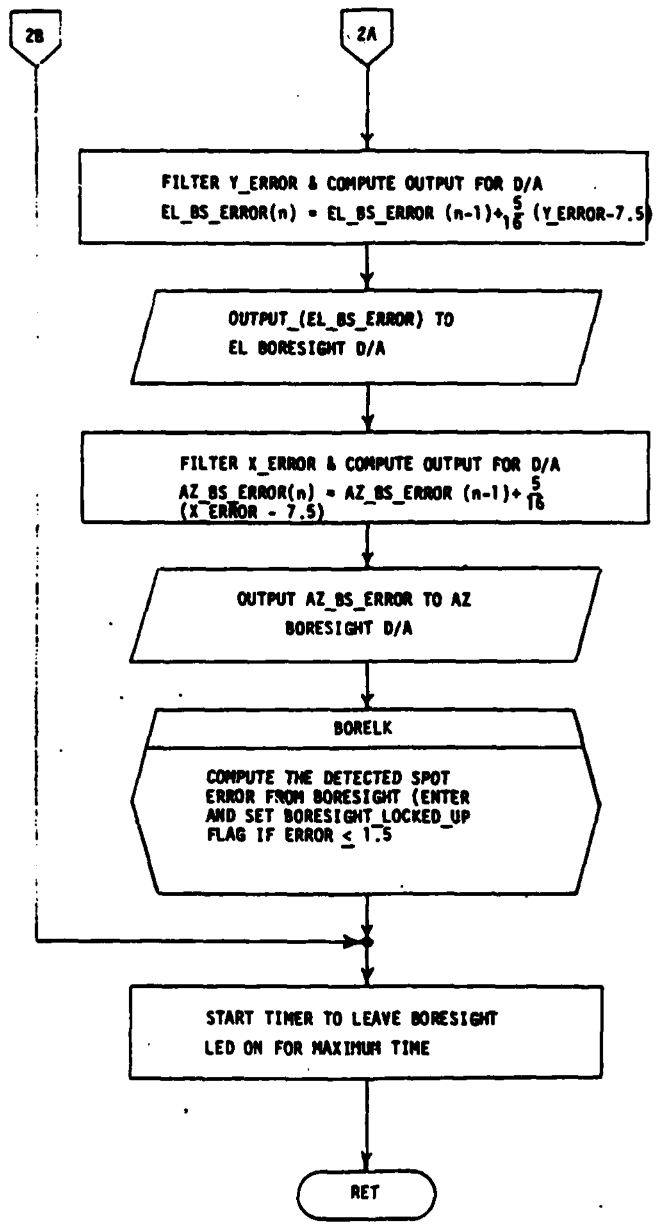

3
COMPUTE MINIMUM(GATSZ)
FDIMX <
MINIMUM (GATSZ)
N
Y
FDIMY <
MINIMUM(GATSZ)
N
Y
TRACK ERRORS<
MAXIMUM
N
Y
GATSZ>0
N
Y
OUTPUT GATSZ-1 TO
TRACK UP
OUTPUT 80H TO
TRACK UP
RETURN


CNVARI
NOTE: ENTERED WITH START OF VECTOR IN H,L CENTROID IN A
QCALC
COMPUTE Q
XTSUM = 0
Y
VARIANCE = Q/XTSUM-(CENTROID -8) * (CENTROID -8)
N
VARIANCE >19
VARIANCE = 19
DIMENSION = DTABLE(VARIANCE).
NOTE: RETURN WITH VARIANCE IN A DIMENSION IN C
RETURN


QCALC
NOTE: START OF VECTOR IN H,L
COMPUTE END OF VECTOR
S = T = R =
VEC(1) + VEC(15)
I = 6
S = S+VEC(8-I) +
VEC(8+I)
T = T + S
Q = R
R = R + T
I = I-1
Y
I ≠ 0
N
Q = Q + R
RETURN


D1 OUT
SIG PROC MAP SELECT = 4:1 VIDEO COMPRESSION (SIG_PROC_MAP = E)
OUTPUT
TO_MAP AND SIG_PROC_MAP TO HARDWARE
OUTPUT
SIGNAL PROCESSOR FLAGS TO TRACK DATA µP (BORESIGHT_LOCKED_UP FLAG, TO_MAP_CHANGE FLAG
RET


AUTOBO
3RD BORESIGHT FIELD
NO
Y
PATTERN_SUM = 0
CLR BORESIGHT_LOCKED_UP FLAG
ZERO
X_SUM =0
Y_SUM =0
SRCH
SEARCH "LEFT HALF" OF AUTOBORESIGHT
RAM FOR DETECTED SPOT
SRCH
SEARCH "RIGHT HALF" OF AUTOBORESIGHT
RAM FOR DETECTED SPOT
PATTERN_SUM ≠ 0
NO
Y
COMPUTE CENTROID OF THE DETECTED SPOT
X_ERROR =X_SUM/PATTERN_SUM
Y_ERROR =Y_SUM/PATTERN_SUM
2B
2A


2B
2A
FILTER Y_ERROR & COMPUTE OUTPUT FOR D/A
EL_BS_ERROR(n) = EL_BS_ERROR (n-1)+$\frac{5}{16}$ (Y_ERROR-7.5)
OUTPUT_(EL_BS_ERROR) TO
EL BORESIGHT D/A
FILTER X_ERROR & COMPUTE OUTPUT FOR D/A
AZ_BS_ERROR(n) = AZ_BS_ERROR (n-1)+$\frac{5}{16}$
(X_ERROR - 7.5)
OUTPUT AZ_BS_ERROR TO AZ
BORESIGHT D/A
BORELK
COMPUTE THE DETECTED SPOT
ERROR FROM BORESIGHT (ENTER
AND SET BORESIGHT_LOCKED_UP
FLAG IF ERROR ≤ 1.5
START TIMER TO LEAVE BORESIGHT
LED ON FOR MAXIMUM TIME
RET

FRAME COUNT	FRMCNT	
NEW-MAP	MAPN	
NEW-TD-MAP	TDMAPN	THE NEWLY COMPUTED MAP FOR THE TD PROCESSOR
TD-MAP	TDMAP	THE CURRENT VIDEO MAP THAT THE TD PROCESSOR IS USING
SIG-PROC-MPA	SPMAP	" " " " " " SP " " "
MPA-SAME-FRM-COUNT	MAPCNT	THE NUMBER OF CONSECUTIVE FRAMES IN WHICH THE NEW COMPUTER
		MAP IS THE SAME.
INNER-HISTOG (n)	HISTIN(n)	THE 16 INNER HISTOGRAM MASS VALUES
OUTER-HISTOG (n)	HISTO(n)	" " OUTER " " "
TARGET-SUM(n)	TGT(n)	THE 4 COMPUTED TARGET SUMS
SUM(n)	SUM(n)	" 4 " INNER HISTOGRAM SUMS
SIG-PROC-FLAGS-WORD	SPFLGS	SIGNAL PROCESSOR STATUS FLAGS-SENT TO TD PROCESSOR
MAX-TARGET-SUM	-	THE MAXIMUM OF THE 3 SUMS OF THE PAIRS OF CONTIGUOUS
		TARGET SUM
MAX-SUM	-	THE MAXIMUM OF THE 3 SUMS OF THE PAIRS OF CONTIGUOUS
		INNES HISTOGRAM SUMS.
X-ERROR	XERR	DETECTED HORIZONTAL ERROR IN BORESIGHT SPOT LOCATION
Y-ERROR	YERR	" VERTICAL " " " " "
X-SUM	XSUM	THE HORIZONTAL SUM OF THE DETECTED BORESIGHT SPOT
Y-SUM	YSUM	" VERTICAL " " " " " "
PATTERN-SUM	PSUM	THE TOTAL AREA OF THE DETECTED AUTOBORESIGHT LED SPOT
AZ-BS-ERROR	XOLD	AZIMUTH BORSIGHT ERROR OUTPUT TO BORESIGHT D/A
EL-BS-ERROR	YOLD	ELEVATION " " " " " "
BORESIGHT-LOCKED-UP FLAG	BORFLG	2 IF THE AUTOBORESIGHT LOOP IS LOCKED UP
RE-ACQUIRE FLAG	-	REQUIRE FLAG-SET TO 1 IF A NEW MAP SHOULD BE TAKEN
AUTO-TRK FLAG	-	1 IF AUTO TRACK IS COMMANDED
SP-RE-ACQUIRE FLAG	REACQ	1 IF A NEW MAP IS REQUIRED
MAP-CHANGE FLAG	MAPCHG	
TD-MAP-CHANGE FLAG	TDMPCH	1 IF
NO-NEXT-LEVEL-MAP FLAG	NOMAP	IF NO NEXT LEVEL MAP HAS BEEN FOUND

APPENDIX D - CORRESPONDENCE

DEPARTMENT OF THE ARMY Mr. Milway/dlw/283-3906
HEADQUARTERS, U.S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

S: 31 Oct 77
15 Apr 78

DRSTE-RU 26 OCT 1977

SUBJECT: Test Directive for FY 78 US Army Aberdeen Proving Ground Instrumentation Development Program

Commander
US Army Aberdeen Proving Ground
ATTN: STEAP-MT-S/MT-G
Aberdeen Proving Ground, MD 21005

1. Reference is made to:

a. TECOM Regulation 70-3, Instrumentation Development and Acquisition Plan, dated 2 Aug 76.

b. Instrumentation Development and Acquisition Program, FY 78 - 82, US Army Aberdeen Proving Ground, dated March 1977.

2. The FY 78 Instrumentation Development Program for US Army Aberdeen Proving Ground will consist of the continuation of one project, ADAPT, for which TECOM Project No. 5-CO-APO-ADP-601 will continue, funded for $66,000, and two new projects: Fire Control All Weather, TECOM Project No. 5-CO-APO-FCW-807, funded for $100,000 and Projectile Motion Determination, TECOM Project No. 5-CO-APO-MRP-801, funded for $50,000. This testing is assigned for accomplishment in accordance with content of reference 1a and as documented in reference 1b and supplements thereto. Full documentation in accordance with reference 1a should be provided NLT 31 Oct 77 for the Projectile Motion Determination effort.

3. Transcript Sheets, STE Forms 1188 and 1189, reflecting test directive establishment into TRMS/ITRMS active files are inclosed.

4. Request this directive and accompanying test event schedules be immediately reviewed and required actions taken in accordance with paragraph 2-4 of TECOM Regulation 70-8.

5. Obligation authority for $216,000 of FY 78 D623 funds will be forwarded by AMC Form 1006 for these efforts. The funding for Fire Control All Weather has been reduced by $64,000 due to a DARCOM reduction of funding.

PJ1-393-0039

DRSTE-RU 26 OCT 1977

SUBJECT: Test Directive for FY 78 US Army Aberdeen Proving Ground Instrumentation Development Program

Restoration of this $64,000 is contingent upon DARCOM restoration of guidance. US Army Aberdeen Proving Ground is requested to provide a schedule of obligation of the $216,000 to this headquarters, ATTN: DRSTE-RU, NLT 31 Oct 77.

6. An interim report on these tasks is required in accordance with reference 1a by 15 Apr 78. This headquarters will review progress and obligation status at that time. Reprogramming of funds will be initiated immediately if significant deviations from schedules are evident.

FOR THE COMMANDER:

Frederick W. Mabranta
for JOHN D. PHELPS
Director
Instrumentation Directorate

5 Incl
as

CF:
Cdr, WSMR, ATTN: STEWS-ID-SR

APPENDIX E - REFERENCES

1. Cunningham, H. V., Harley, S. F., and Paules, P. L., RDI Task Final Report of Automated Data Acquisition and Processing Technology (ADAPT), TECOM Project No. 5-CO-APO-ADP-601. US Army Aberdeen Proving Ground. Report No. APG-MT-5292, November 1979. (Distribution unlimited. AD A073439.)

2. Cunningham, H. V., Harley, S. F., and Wallace, J. R., DIVADS Check Test Instrumentation. Report No. MAD-001, April 1982.

APPENDIX F - ABBREVIATIONS

ADC	= analog to digital convertor
CCD	= charge coupled device
DAC	= digital to analog convertor
DIVADS	= Division Air Defense System
DMA	= direct memory access
DT/OT	= design test/operations test
EPROM	= erasable programable read-only memory
FIFO	= first-in first-out
FLIR	= forward looking infrared
FOV	= field of view
F/No.	= a measure of the angular acceptance of a lens
Hz	= hertz
ICOL	= starting column
IROW	= starting row
I/O	= input/output
KHz	= kilohertz
LED	= light emitting diode
LOS	= line of sight
MAD	= minimum absolute distance
MHz	= megahertz
MIDI	= Missed Distance Indicator
mrad	= milliradian
MVR	= muzzle velocity radar
nsec	= nanosecond
PAMS	= Pointing Angle Measurement System
PCM	= pulse code modulation
RAM	= random access memory
RF	= radio frequency
rms	= root mean square
T/No.	= effective f/No. of a lens including lens losses
TTL	= transistor-transistor logic
TVL	= television lines
UART	= universal asynchronous receiver/transmitter
VGS	= vertical gyro system

(Page F-2 Blank)

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